The Clean Development Mechanism and incentives for climate change mitigation in developing countries

Thesis
presented to the Faculty of Arts
of
the University of Zurich
for the degree of Doctor of Philosophy

by

Paula Monica Castro Pareja
of Peru

Accepted in the fall semester 2011 on the recommendation of
Prof. Dr. Katharina Michaelowa,
Prof. Dr. Joyeeta Gupta, and
Dr. Regina Betz

Zurich, 2011

'The only thing that will redeem mankind is co-operation'
Bertrand Russell, 1954

ACKNOWLEDGEMENTS

I wish to thank first and foremost my supervisors, Axel and Katja Michaelowa, for welcoming me into their research group at the University of Zurich and allowing me to pursue this PhD. With his great experience and innovative ideas, with his enthusiasm about climate policy, Axel was very supportive of my work. Despite his busy agenda, he always managed to take some time for very efficient discussions, and he opened the doors for me to meet a large network of experts and to get engaged in the real life of the CDM, the UNFCCC negotiations and policy discussions. Katja, who so openly gave me the freedom to pursue my research, believed in my capabilities from the beginning on, supported my search for funding, and was always there to provide methodological guidance and comment thoroughly on my work.

A special thanks as well to the members of my PhD committee, Regina Betz and Joyeeta Gupta, for their support, their critical comments and their encouragement to look beyond my research questions.

I also wish to thank my other colleagues at the Chair of Political Economy and Development, particularly Martin Stadelmann, Daisuke Hayashi and Florens Flues for the frequent lunchtime discussions about climate policy, for their suggestions to improve my work, and for cooperation in different pieces of research. A special thanks goes to Yuri for those first months in Zurich in which she shared with me both the office and the hurdles of becoming a PhD student, and for being the friend I could turn to during the UNFCCC negotiation meetings in Bonn and all over the world. Thanks as well to Sebastian, Anke, Sophia, Patrick, Aliya, Chris, Lena, Nadim, Franziska, David, Kassandra, Nassima, Monika. Although they never managed to understand all the CDM- and UNFCCC-related acronyms, they have been great teammates, and have made the PhD life more varied and fun, particularly during those champagne meetings. My work has definitely benefitted from their feedback as well.

I am very grateful as well to the members of the peer group PoliNet – for the opportunity to share doubts and successes, to learn together and help each other. Thanks to them I started to learn Swiss German and to broaden my knowledge of political science beyond climate policy.

Finally, a big thanks to my family. To my parents, because they provided me with the best example and education that can be desired, always supported my aspirations and decisions, and taught me that everything is possible with perseverance and common sense. To my brother, because his example made it easier for me to pursue an academic path, and for being so close despite the distance. And to my husband, who shared with me all these PhD days, who was always understanding and caring during those long working days and nights, and who helped me to disconnect and enjoy outdoors and nature when it was necessary. He has been my day-to-day support and balance during this long journey, without which this dissertation would not have been possible.

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

LIST OF ABBREVIATIONS

ACP	Africa, Caribbean and Pacific countries
AOSIS	Alliance of Small Island States
AWG-KP	Ad-Hoc Working Group on Further Commitments for Annex I Parties under the Kyoto Protocol
AWG-LCA	Ad-Hoc Working Group on Long-Term Cooperative Action under the Convention
CAP	European Common Agricultural Policy
CCS	Carbon capture and storage
CDM	Clean Development Mechanism
CDM EB	Clean Development Mechanism Executive Board
CER	Certified Emission Reduction
CFL	Compact fluorescent lamp
COP	Conference of the Parties (to the UNFCCC)
COP/MOP	Conference of the Parties acting as the Meeting of the Parties to the Kyoto Protocol
CPA	Component Project Activities within PoAs
DNA	Designated National Authority
DOE	Designated Operational Entity
EC	European Community
EEA	European Environmental Agency
EIA	Energy Information Administration
ERU	Emission Reduction Unit
ETS	Emissions Trading System
EU	European Union
GHG	Greenhouse gas
IRR	Internal Rate of Return
JI	Joint Implementation
LDCs	Least Developed Countries
LULUCF	Land use, land use change and forestry
MAC	Marginal Abatement Cost
NAMA	Nationally Appropriate Mitigation Action
NPV	Net Present Value

PDD	Project Design Document
PoAs	Programmes of Activities
RE	Renewable energy
SD	Sustainable development
SIDSs	Small Island Developing States
SSA	Sub-Saharan Africa
UN	United Nations
UNEP	United Nations Environment Programme
UNFCCC	United Nations Framework Convention on Climate Change
US	United States
WDI	World Development Indicators
WTO	World Trade Organization

SUMMARY

Climate change is increasingly recognized as an urgent threat to humanity, and instruments for promoting international cooperation in reducing the emissions of greenhouse gases (GHG) that generate climate change have been established. The Kyoto Protocol to the United Nations Framework Convention on Climate Change established legally binding emission reduction targets for a group of industrialized countries and economies in transition (Annex I countries). To facilitate the achievement of these targets, it established three flexibility mechanisms: Emissions Trading, Joint Implementation and the Clean Development Mechanism (CDM).

Under the CDM, projects that reduce GHG emissions in countries without emission reduction commitments (non-Annex I or developing countries) can generate certified emission reduction credits (CERs), which can be acquired and used by Annex I parties as part of their mitigation commitments. By providing flexibility on where to reduce emissions, the CDM is expected to reduce the cost of compliance. In addition, the CDM has the second aim of promoting sustainable development in its host countries.

Despite its clear success in terms of number of projects, the CDM has been confronted by criticism of: (i) its unequal geographical distribution; (ii) a failure to generate the expected sustainable development benefits in developing countries; (iii) its focus on cheap emission reduction options, leading to windfall profits; and (iv) its failure to reduce emissions in developing countries beyond those that are offset. As a result, several proposals for reforming the CDM have been put forward.

This dissertation is motivated by the recognition that climate change mitigation needs to be strengthened both in industrialized and developing countries. Its main objective is to analyse empirically the *role of the CDM and some of its reform proposals in creating incentives – or disincentives – for developing country action towards reducing emissions*. Throughout its chapters, four research questions are analysed:

1.- Does the introduction of preferential access measures (such as those adopted unilaterally by the EU in its new Climate and Energy Package) improve the geographical distribution of the CDM?

2.- Does discounting the value of emission reductions with differentiation by host countries improve the geographical distribution of the CDM?

3.- Does the CDM discourage advanced developing countries from taking up emission reduction commitments by exhausting the cheap emission reduction opportunities in these countries and making such commitments more expensive for them to comply with?
4.- Why are there expensive emission reduction projects (with abatement costs above the price of carbon) in the CDM pipeline? Do domestic policies that support such expensive projects have an effect on investment in them under the CDM?

These questions all relate to the central discussion on whether the CDM can generate positive incentives towards climate change mitigation in developing countries. This discussion is presented in Chapter 2. Through an analysis of the relevant environmental economics, political economy and public policy literature, this chapter concludes that the CDM can have both positive and negative incentives on mitigation in developing countries. Five negative incentives were identified, which may affect the amount of emission reductions achieved through the CDM itself, the potential mitigation through domestic climate-friendly policies in developing countries, and the willingness of CDM host countries to adopt future emission reduction targets. Two positive incentives for mitigation were found: the first one is the potential of the CDM to capitalize on the window of opportunity in Least Developed countries (LDCs) and contribute to fostering investment in clean technologies, thereby contributing to a lower long-term emissions path; the second one considers that the CDM may help expensive, immature emission reduction technologies achieve cost effectiveness earlier, by financially supporting their diffusion in developing countries. In summary, I assume that the CDM can generate positive incentives for climate change mitigation in developing countries if: (i) it prevents a lock-in to more emissions intensive technologies in LDCs, by promoting low-carbon investment there; (ii) it creates incentives for a transition towards non-offset mitigation instruments in advanced developing countries; and (iii) it incentivizes investment in expensive and immature low-carbon technologies, contributing to learning effects and cost reductions.

To address the first research question presented above, Chapter 3 analyses the impact of preferential access measures for CDM projects in LDCs on the carbon market and the geographical distribution of the CDM. By addressing this geographical distribution and promoting more CDM projects in LDCs, it is expected that such measures may improve the CDM's contribution to improving the long-term emissions path of these countries. The empirical analysis in Chapter 3, based on a quantitative comparison of several future emission reduction credit supply and demand scenarios, shows that even under quite strict preferential access schemes, LDCs cannot compete with other CDM host countries in terms of supply of CERs to the market.

Chapter 4 answers the second research question by analysing another measure proposed to improve the geographical distribution of the CDM: discounting of the value of emission reduction with differentiation across countries. The analysis, based on the creation of CDM-specific marginal abatement cost curves for four non-Annex I regions under two different discounting schemes, reveals again that even with discounting, the supply of CERs from LDCs is still very small compared to the one from large CDM host countries.

The analysis in these two chapters thus questions the ability of these two measures to achieve the goal of improving the geographical distribution of the CDM. More generally, it also questions the ability of the CDM to significantly address the long-term emissions path of LDCs.

In answering the third research question, Chapter 5 looks at a specific form of perverse incentive that the CDM may be generating in advanced developing countries: the argument that, by exhausting the cheaper emission reduction options in these countries, the CDM will make it more expensive for them to comply with future emission reduction targets. Using again marginal abatement cost curves based on my own estimation of abatement costs of CDM projects, and comparing them to abatement cost curves that represent the theoretical abatement potential in six of the most important CDM host countries, this chapter concluded that the CDM has so far not been large enough to have such an effect, and that there are still many theoretically low-cost abatement opportunities in the analysed host countries.

Finally, in Chapter 6 I look at a way in which the CDM might be contributing to the diffusion of more expensive emission reduction technologies, thus inducing learning effects and cost reductions. The chapter starts from the observation that there are many expensive projects within the CDM portfolio, whose abatement costs cannot be covered under current CER prices. I thus hypothesize that domestic climate-friendly policies might be adding a further financial incentive to these expensive technologies, which, coupled with the CDM subsidy, makes them attractive. This hypothesis – which is the fourth research question of the dissertation - is tested econometrically on the example of policies supporting the investment in renewable energy. Using panel two-part and pooled Heckman selection models, as well as instrumental variables estimation, I analyse the effect of domestic renewable energy support policies on investment in renewable energies under the CDM, after controlling for all other factors that may also have an effect on such investment. The statistical results indicate that national support policies are indeed contributing to make expensive CDM projects possible.

In Chapter 7 of the dissertation, finally, these results are summarized and conclusions are drawn regarding the role of the CDM and its reform proposals for creating incentives for climate change mitigation in developing countries. Some ideas for further research arising from the results of the dissertation are presented.

ZUSAMMENFASSUNG

Der Klimawandel wird zunehmend als eine akute Bedrohung für die Menschheit anerkannt. Instrumente wurden verabschiedet, die die internationale Kooperation zur Verringerung von klimaschädigenden Treibhausgasemissionen fördern sollen. Das Kyoto-Protokoll zur UN Klimarahmenkonvention legte 1997 rechtlich bindende Emissionsminderungsziele für eine Gruppe von Industrie- und Transformationsländern („Annex I" Länder) fest. Um die Erreichung dieser Ziele zu erleichtern wurden drei Flexibilitätsmechanismen eingeführt: *Emissions Trading*, *Joint Implementation* und der *Clean Development Mechanism* (CDM).

Unter dem CDM werden Projekte gefördert, die Treibhausgasemissionen in Entwicklungsländern ohne Emissionsminderungsziele („non-Annex I" Ländern) verringern. Diese Projekte generieren Emissionsreduktionszertifikate („certified emission reduction credits" oder CERs), die von Annex I Ländern erworben und als Teil ihrer Minderungsverpflichtungen benutzt werden können. Der CDM bietet Flexibilität bezüglich der Länder in denen die Emissionen verringert werden können. Dadurch soll er die Kosten der Einhaltung der existierenden Minderungsverpflichtungen für Annex I Länder senken. Darüber hinaus hat der CDM als zweites Ziel, eine nachhaltige Entwicklung in Entwicklungsländern zu fördern.

Im Hinblick auf Projektanzahl ist der CDM offensichtlich erfolgreich gewesen. Jedoch sind mehrere Aspekte dieses Mechanismus scharf kritisiert worden:

- (i) seine ungleichmässige geographische Verteilung in den Herkunftsländern;
- (ii) sein unzureichender Beitrag zur nachhaltigen Entwicklung der Herkunftsländer;
- (iii) sein Fokus auf billige Emissionsminderungsprojekte und die resultierenden übermässigen Gewinne für Projektentwickler; und
- (iv) seine Unfähigkeit, Emissionen in Entwicklungsländern über das Niveau hinaus zu reduzieren, welches für Emissionen in Annex I Ländern kompensiert wird („offsetting").

Als Antwort auf diese Kritik sind mehrere Vorschläge zur Reformierung des CDM ausgearbeitet worden.

Diese Dissertation wurde durch die Erkenntnis angeregt, dass eine Reduktion von Treibhausgasen nur in Annex I Ländern nicht ausreichen wird, um eine gefährliche Störung des Klimasystems zu verhindern. Emissionen müssen also auch in Entwicklungsländern reduziert werden. Das Hauptziel der Dissertation ist die *empirische Analyse der Rolle des CDM – oder eines reformierten CDM – für die*

Erzeugung von positiven – oder negativen – Anreizen für eigene Emissionsreduktionen in Entwicklungsländern. Die sieben Kapitel der Dissertation befassen sich mit vier Forschungsfragen:

1.- Wird die geographische Verteilung von CDM Projekten durch die Einführung einer Förderung für Projekte in den am wenigsten entwickelten Ländern (Least Developed Countries oder LDCs) gleichmässiger gemacht?

2.- Wird die geographische Verteilung des CDMs durch eine auf Länderbasis differenzierte Diskontierung des Wertes der Emissionsreduktionszertifikate (CERs) verbessert?

3.- Werden Schwellenländer vom CDM entmutigt, eigene Emissionsminderungsziele zu übernehmen, weil der CDM die kostengünstigeren Emissionsminderungsmöglichkeiten in diesen Ländern ausschöpft und dadurch die Einhaltung eigener Ziele teurer macht?

4.- Warum gibt es teure Emissionsminderungsprojekte im CDM, deren Vermeidungskosten über dem internationalen CO_2-Preis liegen? Haben nationale Politikmassnahmen, die solche teuren Projekte unterstützen, einen Effekt auf deren Existenz innerhalb des CDM?

Diese Fragen betreffen alle die zentrale Diskussion, ob der CDM positive Anreize für eigene Emissionsreduktionen in Entwicklungsländern schaffen kann. Diese Diskussion wird in Kapitel 2 vorgestellt. Aus einer Analyse der relevanten Literatur in den Bereichen Umweltökonomie, politische Ökonomie und Public Policy lässt sich folgern, dass der CDM sowohl positive wie auch negative Anreize für Emissionsreduktionen in Entwicklungsländern bietet. Fünf negative Anreize wurden identifiziert, die die durch den CDM selbst erreichte Menge an Emissionsreduktionen, die potentielle Reduktionen durch nationale klimafreundliche Politikmassnahmen in Entwicklungsländern, und die Bereitschaft der CDM-Herkunftsländer, zukünftige Emissionsminderungsziele anzunehmen, beeinträchtigen können. Zwei positive Anreize wurden gefunden: der erste ist die Möglichkeit, dass der CDM die Chance ergreift, in den LDCs Investitionen in saubere Technologien zu fördern, und ihnen dabei hilft, einen langfristigen kohlenstoffarmen Entwicklungspfad zu erreichen; der zweite besteht darin, dass der CDM innovativen klimafreundlichen Technologien ermöglicht, früher kosteffektiv und kompetitiv zu werden, indem er ihre Verbreitung in Entwicklungsländern unterstützt.

Ich nehme also an, dass der CDM positive Anreize für Emissionsreduktionen in Entwicklungsländern schaffen kann, wenn (i) er Investitionen in klimafreundliche Technologien in LDCs fördert und dadurch eine Festlegung von Investitionen in emissionsintensivere Technologien verhindert; (ii) er Anreize für eine Transition zu nicht-offsetting Emissionsminderungsinstrumenten in Schwellenländern bietet; und (iii) er Investitionen in innovative klimafreundliche Technologien fördert, wobei er zu Lerneffekten und Kostenreduktionen beiträgt.

Kapitel 3 beantwortet die erste obengenannte Forschungsfrage, indem es die Auswirkungen der Förderung von CDM Projekten in LDCs auf den CO_2-Markt und auf die geographische Verteilung der CDM Projekte analysiert. Es wird erwartet, dass solche Massnahmen die geographische Verteilung des CDM zugunsten von LDCs verschieben, und dadurch den Beitrag des CDM zu einem kohlenstoffarmen Entwicklungspfad in LDCs erhöhen. Die empirische Analyse in Kapitel 3 basiert auf einem quantitativen Vergleich zwischen mehreren zukünftigen Szenarien für Angebot und Nachfrage an Emissionsreduktionszertifikaten. Sie zeigt, dass sogar unter sehr stringenten

Vorzugsbedingungen für LDCs diese Länder nicht mit anderen CDM-Herkunftsländern auf dem CER-Angebotsmarkt mithalten können.

Kapitel 4 befasst sich mit der zweiten Forschungsfrage und analysiert eine weitere Massnahme, die für eine gleichmässigere Verteilung des CDM vorgeschlagen wurde: eine je nach Herkunftsland differenzierte Diskontierung des Wertes der Reduktionszertifikate, die aus CDM Projekten stammen. Die Analyse beruht auf der Erstellung von Grenzvermeidungskostenkurven für den CDM in vier nicht-Annex I Regionen bei zwei verschiedenen Diskontierungsschemen. Sie macht deutlich, dass auch bei Diskontierung das Angebot von CERs aus LDCs noch sehr klein im Vergleich zum Angebot aus grossen CDM-Herkunftsländern ist.

Die Analyse in diesen beiden Kapiteln stellt also die Fähigkeit dieser zwei Massnahmen, die geographische Verteilung des CDMs zu verbessern, in Frage. Allgemein stellt sie auch die Fähigkeit des CDM selbst, den langfristigen Emissionspfad von LDCs signifikant zu beeinflussen, in Frage.

Die dritte Forschungsfrage wird im Kapitel 5 angegangen, indem ein potentieller negativer Anreiz des CDM auf Schwellenländer untersucht wird: die Idee, dass der CDM die günstigsten Emissionsreduktionsmöglichkeiten in diesen Ländern erschöpft, und es dadurch teurer für sie macht, zukünftige Emissionsminderungsziele einzuhalten. CDM-Grenzvermeidungs-kostenkurven werden geschätzt und mit Kurven verglichen, die das theoretische Emissionsreduktionspotential in sechs der wichtigsten CDM-Herkunftsländern darstellen. Diese Analyse zeigt, dass der CDM noch nicht gross genug ist, um einen solchen Effekt zu haben, und dass es noch viele theoretisch günstige Treibhausgasreduktionsmöglichkeiten in den analysierten Ländern gibt.

In Kapitel 6 wird untersucht, ob und wie der CDM die Diffusion von teureren Emissionsreduktionstechnologien gefördert hat, sowie Lerneffekte und Kosteinsparungen ausgelöst hat. Das Kapitel beruht auf der Erkenntnis, dass es beim CDM viele Projekte gibt, deren Emissionsreduktionskosten beim derzeitigen CO_2-Marktpreis nicht gedeckt werden können. Aufgrund dieser Beobachtung treffe ich die Annahme, dass nationale klimafreundliche Politikmassnahmen einen zusätzlichen finanziellen Anreiz für diese Projekte bieten müssen, der sie (zusammen mit dem CDM-Zuschuss) attraktiv macht. Diese Hypothese, die die vierte Forschungsfrage dieser Dissertation darstellt, wird nun ökonometrisch untersucht. Mithilfe von Paneldatenanalysen und Instrumentalvariablen analysiere ich den Effekt von nationalen Politiken zur Förderung erneuerbarer Energien auf Investitionen in erneuerbare Energien innerhalb des CDM, unter Berücksichtigung aller anderen Faktoren, die solche Investitionen auch beeinflussen können. Die statistischen Ergebnisse weisen auf einen positiven Einfluss solcher nationaler Politiken hin.

Alle diese Ergebnisse werden schlussendlich in Kapitel 7 zusammengefasst. Schlussfolgerungen über die Rolle des CDM und der untersuchten Reformvorschläge bei der Schaffung von Anreizen für Treibhausgasminderungen in Entwicklungsländern werden gezogen. Ideen für eine weiterführende Forschung aus den Ergebnissen dieser Dissertation werden dabei diskutiert.

1. INTRODUCTION

'We are not only losing land but also agricultural productivity due to frequent salt water incursion which has affected five square kilometres of our land since 1969…Either our island is sinking or the sea is rising.'

(Jalaluddin Saha, India, in WWF 2007)

'[T]o limit the temperature increase to 2°C above pre-industrial levels, developed countries would need to reduce emissions in 2020 by 10–40% below 1990 levels and in 2050 by approximately 40–95%. Emissions in developing countries would need to deviate below their current path by 2020 […].'

(Gupta et al. 2007a, p. 748)

'The natural next step in the evolution of the Kyoto Protocol, and the climate change regime as a whole, is to create clear opportunities and financial incentives for developing country Parties to participate in international emissions trading if they so choose.'

(AOSIS 2011, p. 43)

In the past two decades, man-made climate change has become increasingly recognized scientifically and politically as a real and urgent threat to humanity and a relevant consideration in shaping future development paths (Parry et al. 2007, pp. 44-47; Solomon et al. 2007, pp. 24-32). It has thus emerged as a rapidly growing international policy arena. Due to the far-reaching implications of the actions needed to tackling the climate change threat, enormous challenges subsist in the political sphere for reaching agreements on how, when and where to act.

Tackling climate change implies several types of complementary responses. Mitigation implies reducing the emissions of anthropogenic carbon dioxide (CO_2) and other greenhouse gases (GHG) to the atmosphere, in order to slow down climate change and prevent it from reaching dangerous levels. It, thus, addresses the causes of climate change. Adaptation aims to reduce the – already occurring – adverse consequences of climate change and to enhance positive impacts. Enabling measures encompass supportive actions towards developing and vulnerable countries, which lack the means or capacity to mitigate or to adapt to climate change by their own. They hence comprise capacity building activities, technology development and transfer and the provision of financial support. While all these types of measures are recognized as important constituents of a successful climate policy regime, the Climate Change Convention and its Kyoto Protocol have so far focused mainly on mitigation measures. The Bali Action Plan, agreed at Conference of the Parties (COP) 13 in 2007, and the subsequent agreements in Copenhagen (COP 15, 2009) and Cancún (COP 16, 2010) provide for a stronger focus on adaptation, financing, capacity building and technology transfer in the framework of a new international climate agreement still under negotiation. These new developments, however, are out of the scope of this dissertation.

Signed in 1992 and ratified by 195 parties so far, the United Nations Framework Convention on Climate Change (UNFCCC) was the first international treaty agreed to promote global action towards preventing dangerous climate change. The Convention has the objective of achieving a 'stabilization of greenhouse gas concentrations in the atmosphere at a level that would prevent dangerous anthropogenic interference with the climate system' (UN 1992, Art. 2). While it asks parties to report on progress towards this goal and also states the aim, for a group of countries, to return to the 1990 levels of GHG emissions, it lacks legally binding emission reduction targets for individual countries and an enforcement and compliance system. The UNFCCC places the heaviest responsibility for combating climate change on 27 industrialized countries and 12 economies in transition, which are the source of most past and current GHG emissions. Based on its principle of common but differentiated responsibilities (UN 1992, Art. 3.1), and acknowledging that economic development is vital for developing countries, the Convention accepts that their emissions will continue to rise in the foreseeable years (UN 1992, chapeau). It nevertheless intends to help these countries to limit their emissions without compromising their growth.

The Kyoto Protocol, the first legally binding treaty under the Convention, was adopted in 1997 and entered into force in February 2005. As of July 2011, 192 countries and the European Union are parties to the Protocol. Under Article 3.1 of the Kyoto Protocol (UN 1998), industrialized countries (known as Annex I or Annex B Parties)[1] agreed to reduce their aggregate GHG emissions to at least 5% below 1990 levels by 2008-2012.[2]

From a macro-economic perspective, mitigation implies adopting low greenhouse-gas processes and technologies, ideally without slowing growth and development. In general, it is accepted that mitigation measures are more expensive in industrialized countries, where efficient and state-of-the-art technologies are more common (Stern 2007, pp. 245-246). Furthermore, as climate change is a global problem, in terms of the environmental outcome it does not matter where the emission reductions take place, but how much is reduced overall. Hence, to facilitate that Annex I countries achieve their emission reduction targets in a cost-effective manner, the Kyoto Protocol established three market-based flexible mechanisms: International Emissions Trading, Joint Implementation (JI) and the Clean Development Mechanism (CDM). The first mechanism allows for trading of emissions allowances between countries with reduction targets, while JI refers to investment in

---

[1] Annex I of the UNFCCC lists the industrialized countries that were members of the OECD (Organization for Economic Co-operation and Development) in 1992, plus countries with economies in transition, including the Russian Federation, the Baltic States, and several Central and Eastern European States. Under the Convention, these countries agreed to reduce GHG emissions to 1990 levels by the year 2000. Annex B of the Kyoto Protocol is an update of Annex I and lists those industrialized countries with mandatory emission reduction targets for the period 2008-2012. Countries in both lists are the same, except for Belarus and Turkey that do not appear in Annex B, and the US, which has not ratified the Kyoto Protocol. Following the commonly used terminology, throughout this dissertation the terms 'industrialized countries' and 'Annex I countries' will be used indistinctly to denote those countries that currently have emission reduction commitments under the Kyoto Protocol. Countries without such emission reduction commitments will be denoted 'developing countries' or 'non-Annex I countries'. It should be noted however that this concept of developing countries also includes rapidly industrializing economies such as China, south-eastern Asian countries, and others.

[2] Due to the fact that the US did not ratify the Kyoto Protocol, this overall target will likely not be met.

emission reduction projects in other Annex I countries, and the CDM allows for emission reduction or sequestration projects in developing countries without emission targets (non-Annex I countries). CDM projects generate certified emission reduction credits (CERs)[3] that can be acquired by Annex I parties and used for offsetting emissions in excess of their targets. Because CERs are used for offsetting (or compensating for) emissions made in Annex I countries, the CDM does not lead to more emission reductions, but only to a reduction in the cost of achieving the Annex I targets.

The CDM is thus the only Kyoto Protocol instrument in which developing countries participate in climate change mitigation. It has the double aim of ensuring cost-effectiveness of mitigation measures, while at the same time assisting 'Parties not included in Annex I in achieving sustainable development and in contributing to the ultimate objective of the Convention' (UN 1998, Art. 12.2). The need to ensure that CDM projects have an equitable geographic distribution across host developing countries emerged as a condition for the CDM's second aim to be fulfilled (UNFCCC 2001b, p. 20).

In order to ensure that the CDM fulfils its double aim, a complex project cycle and governance system was established (see Figure 1.1). Proposed CDM projects first need to be approved by the Designated National Authority (DNA) of the country in which the project is located, which establishes the necessary criteria for the project to contribute to the country's sustainable development priorities. A standardized Project Design Document (PDD) describing the project's aims, baseline calculation,[4] additionality determination,[5] estimated emission reductions, monitoring plan and environmental impacts needs to be submitted to an independent auditor (the Designated Operational Entity or DOE), who validates that the project fulfils all the requirements for registration. Once the project has been validated, its registration by the CDM Executive Board (EB) is requested.[6] If three or more members of the EB consider that some of the CDM requirements are not clearly substantiated, the project is subject to a review, otherwise it is registered. A review may result in requests for corrections; once these are fulfilled the project is registered, otherwise it is rejected. Once a project is registered, its emission reductions need to be monitored continuously and reported each year. A DOE verifies the monitoring report, and if everything is correct, the CDM EB issues the corresponding CERs. Here again, if the CDM EB detects any problems in the verification

---

[3] CERs (Certified Emission Reductions) are the trading currency of the CDM. One CER corresponds to one tonne of CO_2-equivalent emission reductions. Once a project's reductions have been verified and certified by an independent auditor (so-called validator), it is issued the corresponding amount of CERs, which can be traded (or have been traded in advance) in the international carbon market.

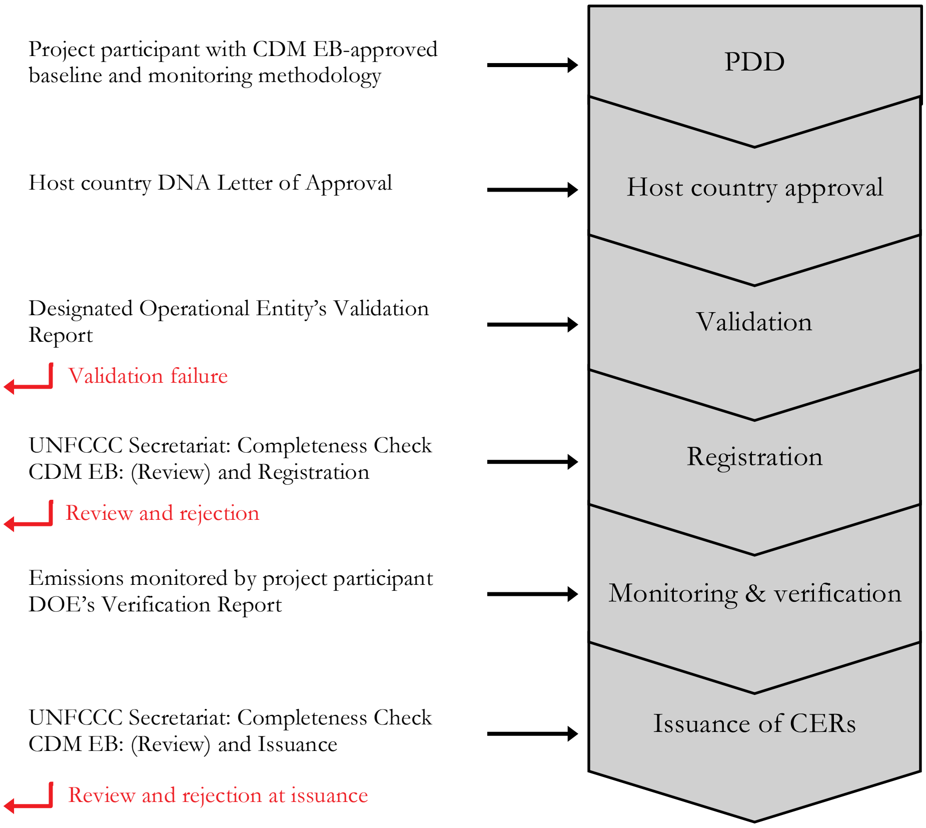
[4] A CDM project's baseline is the 'scenario that reasonably represents the anthropogenic emissions by sources of greenhouse gases that would occur in the absence of the proposed project activity' (UNFCCC 2005a, p. 16). It is thus the basis upon which the emission reductions accruing from a project are calculated.

[5] A CDM project is said to be additional if 'anthropogenic emissions of greenhouse gases by sources are reduced below those that would have occurred in the absence of the registered CDM project activity' (UNFCCC 2005a, p. 16), this is, if it demonstrates that the situation without project (baseline) is the most credible course of action in the absence of the CDM incentive. A more detailed discussion of the concept can be found in the introduction to Chapter 4 of this dissertation.

[6] The CDM EB is the body that supervises the operation of the CDM, and is responsible, inter alia, for the accreditation of DOEs, the approval of baseline and monitoring methodologies, the provision of recommendations to the COP/MOP on further modalities and procedures of the CDM, maintenance of a database of all projects, and the provision of guidance to CDM projects. The EB is fully accountable to the COP/MOP (UNFCCC 2005b). For fulfilling these tasks, it is assisted by several advisory bodies, such as the Methodologies Panel, the Accreditation Panel, the Registration and Issuance Team, the Small-Scale Working Group, the Afforestation and Reforestation Working Group, as well as the UNFCCC Secretariat.

of the monitoring report, it may request a review of the proposed issuance of CERs (UNFCCC 2005a).

Figure 1.1: The CDM's project cycle



Source: Adapted from (UNFCCC n.d.).

At first sight, the statistics about the CDM depict the large success of this mechanism so far: with 3337 registered projects in 70 countries as of August 2011, the CDM is expected to reduce almost 500 million tCO_2e emissions per year. Another 3222 projects still in the process of validation or registration will add about 380 million tCO_2e annual reductions if they are successful (UNEP Risoe Centre 2011b).

Substantial criticism has nonetheless overshadowed this success. Firstly, CDM projects are highly concentrated in a few advanced developing countries, particularly China, India and Brazil. While this geographical distribution closely mirrors the available emissions reduction potential and the investment conditions in the host countries (Dolšak and Crandall 2007; Flues 2010; Lütken 2011; Winkelman and Moore 2011), it is perceived by some parties as unequal (see e.g. Government of Sri Lanka (2008, p. 24)), particularly in view of the benefits the CDM is expected to generate for the host countries: besides financial flows for emission reductions, technology transfer and sustainable development benefits. The complexity of the CDM's project cycle and the high transaction costs that it entails make it comparatively more difficult for poor countries and small projects to access the mechanism (Ellis and Kamel 2007).

Secondly, many CDM projects have not brought about the expected sustainable development benefits, and in some cases there are substantial doubts about their social and environmental integrity (Lenzen et al. 2007; Borges da Cunha et al. 2007; Rudolph 2007; Sirohi 2007; Cole and Roberts 2011). While several schemes about how to effectively assess the sustainable development contribution of CDM projects have been proposed in the literature (e.g. Sutter and Parreño 2007; Olsen and Fenhann 2008), due to sovereignty concerns it is the prerogative of the host countries to decide upon and assess such sustainability criteria. Schneider (2007, p. 46) points out that '[g]enerally, it can not be observed that host countries prioritize projects with high sustainable development impacts by rejecting projects with little or no sustainable development impact'.

Thirdly, the quality of the achieved emission reductions – in terms of being "real" and "additional" – has repeatedly been put into question (Michaelowa and Purohit 2007; Schneider 2007; Castro and Michaelowa 2008; Haya 2009). If emission reductions from CDM projects are not real but just artefacts of accounting tricks, then the mechanism is actually leading to an increase in emissions to the atmosphere.

Fourthly, the CDM, relying on the market, focuses mostly on the cheap emission reduction options, leading to high rents and windfall profits for project developers (Wara 2008), and/or to the fear that selling the cheap emission reduction opportunities now will make mitigation in developing countries more expensive later (World Bank 2003, pp. 31-32).

Finally, given the size of the mitigation challenge, not only industrialized countries need to have more ambitious emission reduction targets, but also developing countries need to contribute to reductions beyond offsetting (Gupta et al. 2007a). Demands for reforming the CDM, or creating other market mechanisms, so that corresponding incentives for developing countries are created, have become louder since Copenhagen, and the academic discussion has also embraced proposals on how to reform the CDM so that it can contribute to emission reductions beyond offsetting (see e.g. Schneider 2009).

The CDM is a very innovative instrument. It is hence bound to have deficiencies. Table 1.1 presents an overview of the developments that the CDM has experienced since its creation, on the basis of the decisions taken by the COP and the COP/MOP (the Conference of the Parties acting as the Meeting of the Parties to the Kyoto Protocol) each year. The table makes clear that, besides continuous managerial and operational improvements to the CDM, including transparency of EB decisions, several larger issues have been discussed (and in most cases solved) over time, such as:

- the non-eligibility of policies as CDM projects, but the possibility to register programmes of activities as single projects;
- whether new project categories, such as new HFCF-22 facilities, carbon capture and storage (CCS), or forests in exhaustion can be considered CDM projects;

- improvements to the demonstration of additionality;
- improvements to the governance of the CDM and the competences of all the involved bodies, including the work of DOEs, through e.g. an accreditation standard and a manual;
- several measures to improve the geographical distribution of the CDM, such as the identification of barriers, the launch of the Nairobi Framework, the elimination of fees for projects in Least Developed Countries, and more recently, the establishment of a loan scheme for CDM project development in underrepresented countries, and the development of top-down methodologies appropriate for their circumstances;
- the simplification of baseline methodologies, e.g. through establishing simple methods for small-scale and micro-scale projects, and through the development of standardized baselines;
- the treatment of national policies that support emission reductions in relation to the CDM.

But negotiations about how to improve the CDM have also been embedded in a larger effort to agree on a new (or improved) climate change regime for the period after 2012. The entry into force of the Kyoto Protocol in 2005 and the recognition of the need to continue the efforts to combat climate change after the end of its first commitment period in 2012 led to renewed negotiations in the climate regime. In December 2005, the Ad-Hoc Working Group on Further Commitments for Annex I Parties under the Kyoto Protocol (AWG-KP) was created in order to decide upon new emission reduction targets for Annex I parties after 2012. In December 2007, within the process of periodic review of the Kyoto Protocol established in its Article 9, the COP/MOP decided that the second review shall consider, among other topics, '[t]he scope, effectiveness and functioning of the flexibility mechanisms, including ways and means to enhance an equitable regional distribution of clean development mechanism projects' (UNFCCC 2008d, p. 19). Also in December 2007, the Bali Action Plan agreed at COP 13 created the Ad-Hoc Working Group on Long-term Cooperative Action under the Convention (AWG-LCA), which negotiates a new agreement that will enable the broader implementation of the Convention.

The negotiations in these fora include further proposals on how to address the different shortcomings of the CDM described above, and on the role of the CDM and other market or non-market mechanisms in the post-2012 climate change regime. See, e.g. UNFCCC (2008a; 2008e) for syntheses of proposals relating to the CDM made under the Subsidiary Body for Implementation and under the AWG-KP. While some of these proposals – particularly those related to reforming the CDM – are already being implemented, as shown in Table 1.1, and others – especially those related to other mechanisms – are still under discussion, there has been very little empirical research on their expected effects on climate change mitigation in the South.

This dissertation is thus motivated by the recognition that climate change mitigation needs to be strengthened, both in industrialized and developing countries. As the quotations at the beginning of this introduction illustrate, addressing the causes of climate change requires ambitious action by all countries. While this dissertation does not deny that such efforts are to be lead by industrialized countries, through emission reduction targets that need to be much more ambitious than they are at present, its focus is on incentives for action by developing countries.

Table 1.1: Progress made on improvement of the CDM under the COP and the COP/MOP

Meeting	Place and year	Decision number	Decision name	Description of substantial decisions on the CDM
COP7	Marrakesh, 2001	Decision 17/CP.7	Modalities and procedures for a clean development mechanism, as defined in Article 12 of the Kyoto Protocol	Establishes the modalities and procedures of the CDM, standards for the accreditation of DOEs, a description of the PDDs, terms of reference for guidance about baseline and monitoring methodologies, registry of the CDM.
COP8	New Delhi, 2002	Decision 21/CP.8	Guidance to the Executive Board of the clean development mechanism	Adopts the rules of procedure for the EB. Adopts simplified modalities and procedures for small-scale CDM projects.
COP9	Milan, 2003	Decision 18/CP.9	Guidance to the Executive Board of the clean development mechanism	Amends part of rules of procedure of the EB. Adopts procedures for review of registration of CDM projects.
		Decision 19/CP.9	Modalities and procedures for afforestation and reforestation project activities under the clean development mechanism in the first commitment period of the Kyoto Protocol	Adopts modalities and procedures for afforestation and reforestation projects under the CDM.
COP10	Buenos Aires, 2004	Decision 12/CP.10	Guidance relating to the clean development mechanism	Adopts procedures for review of issuance of CERs. Adopts amendments to rules of procedure of EB, inter alia to allow electronic communication. Recommends the EB to keep the additionality tool under review for improvement. Asks SBSTA for a recommendation on implications of CDM projects in new HFCF-22 installations for the objectives of Montreal Protocol. Requests the EB to start a database of approved methodologies. Requests the EB to intensify work on ensuring the good functioning of the CDM, e.g. through a management plan, strengthening of institutional capacity, and transparent decisions.
		Decision 13/CP.10	Incorporation of the modalities and procedures for afforestation and reforestation project activities under the clean development mechanism into the guidelines under Articles 7 and 8 of the Kyoto Protocol	Describes how parties should account for CERs, tCERs and lCERs in their national inventories and registries.
		Decision 14/CP.10	Simplified modalities and procedures for small-scale afforestation and reforestation project activities under the clean development mechanism in the first commitment period of the Kyoto Protocol and measures to facilitate their implementation	Adopts simplified modalities and procedures for small-scale afforestation and reforestation CDM projects.

Meeting	Place and year	Decision number	Decision name	Description of substantial decisions on the CDM
COP/ MOP1	Montreal, 2005	Decision 3/CMP.1	Modalities and procedures for a clean development mechanism as defined in Article 12 of the Kyoto Protocol	Confirms the modalities and procedures agreed upon under Decision 17/CP.7.
		Decision 4/CMP.1	Guidance relating to the clean development mechanism	Confirms the agreements under Decisions 21/CP.8, 18/CP.9 and 12/CP.10.
		Decision 5/CMP.1	Modalities and procedures for afforestation and reforestation project activities under the clean development mechanism in the first commitment period of the Kyoto Protocol	Confirms the agreement under Decision 19/CP.9 on modalities and procedures for afforestation and reforestation projects.
		Decision 6/CMP.1	Simplified modalities and procedures for small-scale afforestation and reforestation project activities under the clean development mechanism in the first commitment period of the Kyoto Protocol and measures to facilitate their implementation	Confirms the agreement under Decision 14/CP.10 on simplified modalities and procedures for small-scale afforestation and reforestation projects.
		Decision 7/CMP.1	Further guidance relating to the clean development mechanism	Requests inputs with the aim of taking a decision on how to consider CCS as a CDM project. Requests the EB to make some improvements to the CDM management plan. Requests the EB to develop a catalogue and guide to its decisions, and ensure that decisions are appropriately explained. Gives the EB authority to establish panels, committees and working groups and define their functions; clarifies supportive role of the Secretariat towards the EB. Decides that policies or standards cannot be considered as CDM projects, but that programmes of activities can be registered as a single project; allows for bundling of large-scale projects. Requests submissions on barriers to the equitable distribution of projects.
		Decision 8/CMP.1	Implications of the establishment of new hydrochlorofluorocarbon-22 (HCFC-22) facilities seeking to obtain certified emission reductions for the destruction of hydrofluorocarbon-23 (HFC-23)	Adopts a definition for "new HCFC-22 facilities" and requests the SBSTA to continue deliberating on the topic.

Meeting	Place and year	Decision number	Decision name	Description of substantial decisions on the CDM
COP/ MOP2	Nairobi, 2006	Decision 1/CMP.2	Further guidance relating to the clean development mechanism	Allows EB to suspend/reinstate accreditation of DOEs in between sessions of the COP/MOP. Encourages EB to continue with managerial improvements. Requests the EB to develop guidance for DOEs on validation and verification. Requests EB to finalize guidance on PoA and work on improving the additionality tool. Requests EB to keep considering possibility of CCS as a CDM project, parties to make further submissions on issues related to CCS, and SBSTA to prepare recommendations on it. Revises the definition of small-scale projects. Launches the "Nairobi Framework" to promote CDM projects in Africa. Requests EB information on regional distribution and barriers for CDM.
COP/ MOP3	Bali, 2007	Decision 2/CMP.3	Further guidance relating to the clean development mechanism	Welcomes approval of guidelines and procedures for PoAs. Requests EB to improve management and operation of CDM project cycle (e.g. Validation and verification manual, better substantiation of decisions, streamlining and transparency of minor issues). Abolishes payment of registration fees and share of proceeds for CDM projects in LDCs.
		Decision 4/CMP.3	Scope and content of the second review of the Kyoto Protocol pursuant to its Article 9	Requests submissions on how to address in the second review "the scope, effectiveness and functioning of the flexibility mechanisms, including ways and means to enhance an equitable regional distribution of clean development mechanism projects".
		Decision 9/CMP.3	Implications of possible changes to the limit for small-scale afforestation and reforestation clean development mechanism project activities	Revises the limit for small-scale afforestation and reforestation activities under the CDM.
COP/ MOP4	Poznan, 2008	Decision 2/CMP.4	Further guidance relating to the clean development mechanism	Requests EB to make recommendations on how to improve operation of CDM. Welcomes approval of validation and verification manual and the adoption of timelines for some tasks - requests timelines for other tasks and urges speeding up of completeness check. Requests work on a hierarchy of EB decisions. Requests several measures to improve transparency, quality and independence of DOEs, e.g. accreditation standard. Requests EB to enhance objectivity of approaches to demonstrate additionality. Requests EB to continue work on guidance for PoAs. Requests the EB to assess implications of including CCS and forests in exhaustion under the CDM. Requests EB to develop ways to streamline project cycle for countries with less than 10 registered projects.

Meeting	Place and year	Decision number	Decision name	Description of substantial decisions on the CDM
COP/ MOP5	Copenhagen, 2009	Decision 2/CMP.5	Further guidance relating to the clean development mechanism	Welcomes measures to improve efficiency of CDM operations, and requests these efforts to continue. Request for improvement of communications between EB and project participants. "Affirms that it is the prerogative of the host country to decide on the design and implementation of policies to promote or give competitive advantage to low greenhouse gas emitting fuels or technologies"; and requests the EB to ensure that related rules "do not create perverse incentives for emission reduction efforts"; thus requests it "to consolidate, clarify and revise, as appropriate, the guidance on the treatment of national policies". Requests EB to undertake several measures to enhance objectivity and transparency of additionality demonstration and baseline setting. Requests SBSTA to recommend modalities and procedures for developing standardized baselines for the CDM, and requests parties to submit views on this. Requests new procedures for project registration, issuance and review, including an appeals procedure. Decides that payment of registration fee be deferred until first issuance for countries with less than 10 registered projects; requests development of top-down methodologies for projects suitable in these countries; requests EB to provide loans to support PDD development, validation and first verification in countries with less than 10 registered projects.
COP/ MOP6	Cancun, 2010	Decision 3/CMP.6	Further guidance relating to the clean development mechanism	Requests reassessment of PoA rules regarding additionality and eligibility of CPAs and simplification of multi-method programmes. Endorses ToRs for membership to the EB. Requests further work on appeals procedure. Requests further work on improving communication channels. Welcomes work on simplified modalities for micro-scale projects, and to continue work on this. Defines standardized baselines and requests EB to develop them prioritizing methodologies that are applicable to underrepresented countries. Endorses revised procedures for registration, issuance and review. Requests accelerated work on top-down methodologies for underrepresented countries. Decides on source of loans for projects in underrepresented countries; adopts guidelines and modalities for operationalization of the loans scheme.
		Decision 7/CMP.6	Carbon dioxide capture and storage in geological formations as clean development mechanism project activities	Makes CCS eligible as CDM project, provided outstanding issues are addressed and resolved adequately, and requests SBSTA to elaborate related modalities and procedures.

Source: UNFCCC and Kyoto Protocol Decisions detailed in table.

In general terms, incentives for emission reduction action are similar for all countries: they will act if the benefits accruing from action are higher than the costs (Olson 1971). As will be described in Chapter 2, the public good nature of the climate makes such cooperation very difficult to achieve, both among industrialized and developing countries. Still, the Kyoto Protocol with its (albeit lenient) targets is a reality, and the negotiations towards a post-2012 climate regime are still (albeit very slowly) moving forward.

Assuming that cooperation is, in general terms, possible, this dissertation looks at the effect of the design of the pre-2012 climate regime on future cooperation by developing countries, specifically at the role of the CDM in creating incentives – or disincentives – for developing country action towards reducing emissions. This implies action that will not only reduce the costs of mitigation elsewhere through offsetting, but that will itself generate short- or long-term emission reductions. Academically, the dissertation thus seeks to contribute to the literatures on international cooperation, environmental economics and public policy design. In practical terms, it expects to provide new insights in the analysis of proposals to reform the CDM.

For doing this, the dissertation relies on three general assumptions about how the CDM may create positive incentives towards reducing emissions in developing countries:[7]

(1) Positive incentives can be created if the CDM is successful in facilitating investment in low-carbon technologies in countries in which these technologies would otherwise be out of reach. Even if CDM credits are used for offsetting, the investments incentivized would generate a more climate-friendly long-term development path and prevent a lock-in to emissions intensive technologies. I assume that this condition is applicable to Least Developed Countries (LDCs), in which poverty alleviation concerns have a clear priority over global environmental goals.
(2) In countries that are already able to afford less emissions-intensive technologies (advanced developing countries),[8] the CDM can create positive incentives by setting the ground for a transition towards non-offset mitigation instruments.
(3) Both in advanced and in less developed countries, the CDM can incentivize mitigation if it promotes investment in low-carbon technologies that are not yet completely mature or commercially competitive, contributing to learning and scale effects that make these technologies more competitive in the long term.

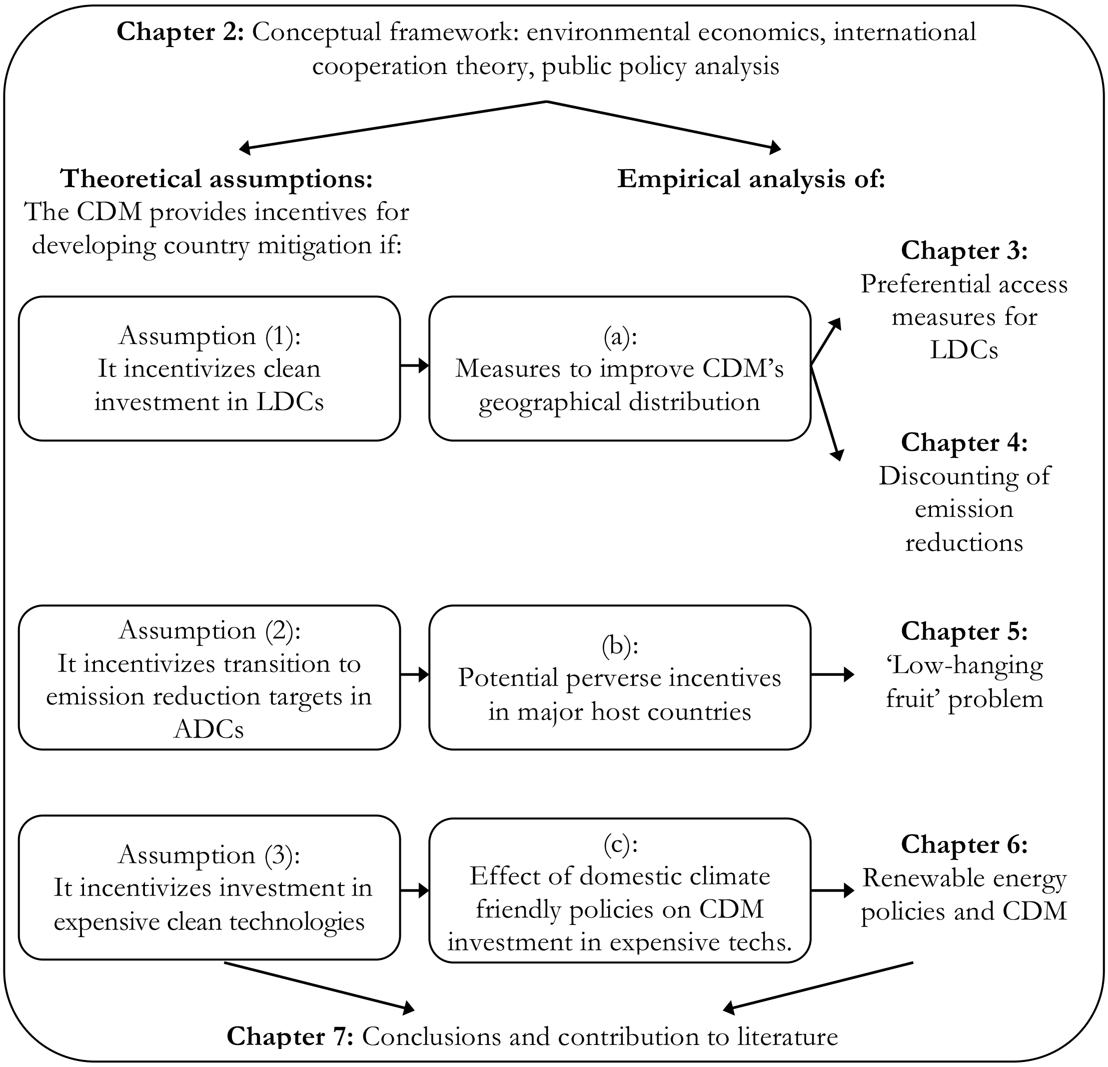
[7] The theoretical rationale behind these assumptions will be explained in detail in Chapter 2.
[8] For the purposes of this dissertation, advanced developing countries are defined on the basis of the principle of common but differentiated responsibilities and respective capabilities, this is, in terms of the countries' responsibility for causing climate change and capabilities for dealing with it. Under this rationale, countries with high GHG emission levels (high responsibility) and with high income per capita (high capability) are considered 'advanced'. I do not define a threshold for how high these indicators should be, as this is a political decision that will eventually need to be negotiated by the UNFCCC parties. However, several authors have proposed different ways of differentiating among developing countries in the climate regime (see e.g. Berk and den Elzen 2001; Ott et al. 2004, p. 26ff; Michaelowa et al. 2005; Karousakis et al. 2008; Bakker et al. 2009).

Starting from these assumptions, I seek to address the gap in empirical research on the potential effects of the CDM and some of its reform proposals on climate change mitigation in the South, through an empirical assessment of:

(a) Concrete measures that have been proposed to address barriers to its implementation in Least Developed Countries (LDCs) and make its geographical distribution more equitable;
(b) Potential perverse incentives that the CDM may generate in its major host countries; and
(c) The effect of domestic climate-friendly policies in non-Annex I countries on investment in expensive emission reduction opportunities through the CDM.

Figure 1.2 graphically presents the structure of the dissertation, in relation to the assumptions and the research objectives listed above. Before proceeding to the empirical analysis, Chapter 2 details the conceptual framework that guides the study.

Figure 1.2: Structure of the dissertation



Chapters 3 and 4 address the objective (a) described above, by looking at measures proposed to generate incentives for increased CDM participation in LDCs and other poor countries with limited emission reduction potential and financial capacity. Such increased participation is desirable from two points of view. On the one hand, LDCs would benefit from more CDM projects because they would generate an inflow of financial resources, technology transfer and, per the CDM's objectives, sustainable development. On the other, while the climate change regime explicitly recognizes the limited capabilities of LDCs (UN 1992, Art. 4.9; Decision 5/CP.7 in UNFCCC 2001a, p. 33), so that they are not expected to undertake mitigation actions on their own, it is desirable that they should achieve growth in a more climate-friendly manner, to avoid a lock-in to high emitting technologies (assumption (1) above). The CDM, which was expected to contribute to this goal, has not been able to do so due to its limited presence in these countries.

The establishment of preferential access measures for CDM projects from LDCs is one of the measures that have been proposed to address the issue of the unequal geographical distribution of CDM projects. While the UNFCCC has granted financial support for projects in underrepresented CDM host countries (UNFCCC 2009), the EU has unilaterally introduced quality restrictions on the CDM projects that will be accepted in its carbon market from 2013 on. Among these restrictions is a clause establishing that, in case no new international climate change agreement is reached, only CERs from LDCs, SIDSs (Small Island Developing States) or countries with bilateral agreements with the EU will be accepted in the European Emissions Trading System (European Parliament 2009b). So far, very little research has been carried out on whether such preferential access measures will have the desired effect of improving the geographic distribution of the CDM. To my knowledge, only a very recent article by Bakker et al. (2011) has assessed the potential impacts of preferential treatment, discounting and other forms of CDM differentiation on the future market. This research, however, was not yet published at the time of writing of the related sections of this dissertation.

In Chapter 3, this gap in research is addressed by assessing the impact of such preferential access measures on the carbon market through the comparison of several emission reduction credit supply and demand scenarios for the post-2012 period. The main methodological contribution of the chapter consists of a new approach for estimating future CER supply on the basis of data on the current CDM pipeline, which is more accurate than a simple aggregation of the existing figures, as it incorporates the effects of failing to achieve registration at the different stages of the CDM project cycle. Furthermore, lessons for preferential treatment for LDCs under the CDM are drawn from a comparison with preferential access measures that have been implemented in the past in another international policy area: agriculture. The contribution of the chapter to the general goals of the dissertation is an empirical exploration of the potential ability of preferential access measures to improve CDM activity in LDCs. The chapter has been written with Axel Michaelowa. My contribution comprises the literature review on the situation and barriers of CDM projects in LDCs and on the existing preferential access measures in the climate regime; the conceptualization of the supply and demand scenarios; data collection and all calculations leading to the estimation of supply and demand of CERs for each scenario; the comparison with the preferential access agreement in agriculture; and writing up. Axel Michaelowa's contribution was on defining the research question; providing the input and discussion for the sections about the role of Programmes of Activities for

CDM in LDCs; he also provided suggestions on relevant parameters for the supply scenarios (e.g. probability of validation, delay function) and had previous work on estimating CER supply for the 2008-2012 period, on which basis the formulae for supply in the 2013-2020 period were built; he provided expert knowledge about possible future pledges by Annex I parties, as the basis for calculating demand from some countries; and made editorial suggestions to the latest versions of the chapter.

Chapter 4 analyses the introduction of discount factors for emission reductions achieved in advanced developing countries and its effect on the geographical distribution of the CDM, with particular focus on LDCs and Sub-Saharan Africa. Under discounting, each tonne of emission reductions achieved through the CDM would have a value of less than one tonne in the international carbon market. Depending on its concrete design, discounting the value of emission credits could be used to compensate for non-additional CDM projects; to increase the incentive for advanced developing countries to move from the CDM to own mitigation commitments (if the discount rates are set up to be more stringent for more advanced countries); and to improve the competitiveness of less developed countries as hosts for CDM projects (Chung 2007; Michaelowa 2008b; Schneider 2009). While there has been substantive discussion in the literature on how discounting of emission reductions could be implemented, and with what purposes it could be used, there has been little analysis on what would be its effects on the carbon market. Stoft (2009) makes a stylized analysis of the effects of discounting (and other proposed reforms of the CDM) on the basis of microeconomic theory, but does not look at implications for geographical distribution of projects. In Chapter 4, the impact of discounting on the competitiveness of CDM host countries is analysed by creating and comparing CDM-specific marginal abatement cost curves for four regions under two different discounting schemes.

This chapter (as well as Chapter 5) relies on the creation of a new dataset of CDM projects' abatement costs, which were estimated on the basis of information provided in the projects' public documentation. The main methodological contribution of the chapter is thus the method for estimating these abatement costs in a credible and comparable manner, the compilation of the dataset, and the presentation and analysis of the information on the basis of marginal abatement cost curves, including the effect of discounting. The chapter was written in collaboration with Axel Michaelowa. My contribution was the literature review on discounting and marginal abatement cost curves; all data collection, methodology and estimation of CDM abatement costs and marginal abatement cost curves, as well as the discussion of these results; writing up of the chapter. Axel Michaelowa's contribution was on the definition of the research question; the definition of the discounting schemes differentiated by host countries; part of the discussion of the effects of discounting on geographical distribution of the CDM; quality control over cost data; and editorial reviews to the latest versions of the chapter.

In a second part of the dissertation (Chapters 5 and 6), I look at the situation for advanced developing countries, which have been successful in the CDM, and which are under pressure for taking on own mitigation actions beyond offsetting soon (objective (b) above). Some undesired perverse incentives that the CDM might generate for the countries that are benefitting the most from it have been identified early on. Firstly, the financial transfers provided by the CDM to developing countries may make them unwilling to depart form the CDM to a more costly emissions reduction target (Wara and Victor 2008; Burniaux et al. 2009; Hagem and Holtsmark 2009). Secondly, the need to demonstrate the additionality of CDM projects may discourage host country governments from adopting policies that may contribute to reduce emissions (Hepburn 2007). Thirdly, even before the full implementation of the CDM, developing country experts feared that it would exhaust the cheap emission reduction opportunities in these countries, leaving them with only more expensive options to address eventual emission reduction targets of their own (World Bank 2003, p. 32; Narain and van't Veld 2008). Such concerns affect the negotiations about the future of the CDM and of other market mechanisms even today.

Chapter 5 thus focuses on analysing whether such a "low-hanging fruits" problem has arisen in the current CDM. Theoretical economic models have been used to analyse under which conditions the low-hanging fruits problem would arise (e.g. Akita 2003; Germain et al. 2007; Narain and van't Veld 2008). However, as these analyses were made before the CDM had started to work, there was no empirical evidence yet of the problem. Chapter 5 addresses this gap by looking empirically at the question whether the CDM has so far exhausted many of the emission reduction opportunities existing in its most successful countries, using again marginal abatement cost curves for six of the countries that currently host most CDM projects, and relying on a larger, self-compiled dataset of CDM project abatement costs. The chapter thus seeks to contribute to the more general discussion on the role of offset mechanisms in achieving global GHG emission reductions.

Among other things, the abatement cost analysis in Chapter 5 reveals that there are some surprisingly expensive projects in the CDM. This appears puzzling from the point of view that rational economic actors would exhaust the cheap emissions abatement opportunities first, before investing in more expensive ones. It also seems to contradict the CDM critics' argument that its focus on cheap credits, coupled with its project-by-project nature and the low carbon price, is not contributing to a real systemic change in energy or industrial systems in developing countries. Chapter 6 investigates this phenomenon starting from the hypothesis that domestic-level financial incentives are contributing to finance relatively expensive CDM projects (objective (c) above). Using econometric techniques, this chapter thus analyses whether domestic policies providing financial incentives to climate friendly projects – specifically renewable energy projects – in developing countries have an effect on the size of the CDM investment in renewable energy projects, after controlling for all other factors that may be influencing such investments as well. This chapter addresses several gaps in the literature. In general terms, I am not aware of any cross-country study that systematically analyses the factors leading to investment in renewable energies, especially in developing countries. While the chapter is focused on renewable energy investments within the CDM, it also controls for other drivers, and analyses in particular the effect of national policies. Furthermore, it combines insights from the general literature on investment in renewable energy, with insights from the more specific literatures on barriers to CDM investment and factors leading to CDM investment, and with the literature on determinants of the adoption of environmentally friendly policies, in order to develop a theoretical framework for the empirical assessment. More specifically, within the literature on the CDM, the discussion about the interaction between national policies and the CDM incentive has been theoretical (e.g. Hepburn 2007) or based on case studies (He and Morse 2010). This chapter provides first systematic empirical evidence that such an interaction exists.

In the last part of the thesis (Chapter 7), a summary of the conclusions and main contributions of this dissertation to the literature are presented.

2. CONCEPTUAL FRAMEWORK

In this chapter, insights from the environmental economics literature on addressing public goods problems – in this case, the Earth's climate – are combined with insights from political economy and public policy on international environmental regimes and their effectiveness, in order to describe the incentives framework in which the Kyoto Protocol's Clean Development Mechanism and its implications for climate change mitigation in developing countries will be analysed empirically later.

2.1 Climate change as a global public good problem

The economics literature describes public goods as those that are non-rival (their enjoyment by an individual does not reduce the possibility for others to enjoy them as well) and non-excludable (no one can be excluded from enjoying them) (Samuelson 1954; Cornes and Sandler 1996, pp. 8-9). The Earth's climate is a public good and as such, in the absence of public policy, there are no incentives to bear the costs of reducing emissions to avoid dangerous climate change, if others will benefit without bearing any costs (free riding problem). It is additionally a global good, both in terms of its causes (greenhouse gases can be emitted anywhere on Earth with the same effect on the atmosphere) and its consequences (while unevenly distributed, dangerous climate change will eventually have impacts worldwide). Furthermore, it is a long-term problem, in which the effects of today's emissions will mostly be felt in the distant future (Stern 2007).

To address global public goods, international cooperation is necessary. The collective action literature emphasizes that, in the absence of coercion from above, actors will cooperate and adopt institutions that regulate the use of the public good only if their private benefits from cooperation are positive (Olson 1971; Ostrom 1990). The climate change problem thus constitutes a setting in which cooperation is very difficult to achieve, because an individual country's mitigation efforts will not bring about positive benefits unless global emissions do not increase. Since most countries' emissions levels are small compared to the total, controlling global emissions depends on the probability that other countries cooperate, which is difficult to enforce in an international setting, thus leading to free-riding problems (Dolšak 2001).

The economics game theoretic literature on the stability of coalitions (e.g. Barrett (1990) and Carraro and Siniscalco (1992; 1997)) explains why in the climate regime, few countries are willing to join the coalition of those cooperating in reducing GHG emissions. It discusses how to expand such coalition and incentivize emission reduction efforts by those countries unwilling to cooperate, and suggests that side payments – trading emission reduction commitments with other benefits such as financial aid, favourable trade policies or technology transfers – are useful in achieving this goal (Kverndokk 1993; Fankhauser and Kverndokk 1996).

In line with the above, the neoliberal school of thought in international relations posits that countries act as self-interested rational actors pursuing absolute gains rather than gains relative to those of other countries, and that cooperation among them can be achieved through international regimes (Keohane and Nye 1989). The focus of analysis is here the international organizations and institutions and their effects on countries' behaviour (e.g. Keohane et al. 1993; Bernauer 1995). This theory can be applied to international environmental agreements, as has been done for example by Sprinz and Vaahtoranta (1994). They argue, also in line with public choice theory, that country delegates negotiating international environmental agreements pursue the interests of their domestic actors, such as preventing the effects of pollution on their own citizens, avoiding high costs of compliance and benefitting their own pollution abatement industry (see also Michaelowa (2000) for an application of the public choice framework to European climate policy).

The Kyoto Protocol's Clean Development Mechanism, which is the focus of this dissertation, can be understood in these terms, as it has been designed with the aim of satisfying the interests of the stakeholders involved in negotiating its creation: industrialized countries looking for ways to reduce the costs of compliance with their emission reduction targets; developing countries interested in attracting foreign investment and transfer of clean technologies; actors that are vulnerable to climate change, interested in ensuring as much mitigation as possible; actors that are looking for business opportunities, such as clean energy providers; and actors advocating fair outcomes, such as a distribution of climate policy obligations according to the polluter pays principle, and a distribution of benefits that is equitable. The CDM as an instrument thus seeks to reconcile environmental integrity ("additionality"), economic efficiency and sustainable development ("equitable geographic distribution") goals, in an attempt to satisfy the preferences of all involved.

As described in the introduction, however, the CDM has not been capable of fully reconciling these goals. Furthermore, new scientific findings make now clear that action towards preventing dangerous climate change needs to be much broader than so far, involving deeper emission cuts by industrialized countries and action towards stabilization of emissions by developing ones. A process of regime transformation has thus started (Young 1982), comprised of the international negotiations towards a new (or reformed) post-2012 climate agreement that is envisaged to improve cooperation.

Insights from the environmental economics, public policy and innovation economics literature are used next to discuss and analyse the attempts that are currently being made to reform and improve the CDM.

2.2 Policy instruments to tackle climate change

In the face of environmental externalities such as those arising in the climate change problem, the environmental economics literature indicates that the costs of the externality need to be internalized – this is, a price needs to be set on the polluting GHG emission – in order to change the incentives structure for the polluters (see e.g. Turner et al. 1993).

The Kyoto Protocol to the UNFCCC thus established a cap-an-trade system. Following the principles of polluter pays and historical responsibility (known in the climate regime as the principle of "common but differentiated responsibilities"), emission targets were only set for the group of industrialized and transition parties listed in its Annex B (for a discussion of the principle of common but differentiated responsibilities, see e.g. Rajamani 2000; Matsui 2002; Hepburn and Ahmad 2005). Cost effectiveness and "when" flexibility (Goulder and Pizer 2006) were granted through the establishment of the three flexibility mechanisms introduced in the previous chapter: international emissions trading, Joint Implementation, and the Clean Development Mechanism.

Emissions trading and Joint Implementation take place among countries with emission reduction targets, so that they provide flexibility without potentially affecting the emission reductions to be achieved. With the CDM, the case is different. In theory, it is a zero sum game: each tonne of emission reductions achieved through the CDM can be used to offset one tonne of emissions in industrialized countries. CDM emission reductions are so to say added to the emissions allowance of the buyer country. However, as it allows to borrow emission reductions from countries that do not have an emissions cap themselves, the achieved reductions cannot be measured against an observable reference level. Thus, CDM project proponents need to demonstrate that their project reduces emissions below an hypothetical (non observable) baseline that would have happened in the absence of the CDM. Furthermore, they have to show that the project would not have happened in the absence of the CDM incentive ("additionality").

This unique feature of the CDM motivated since its beginnings a vast literature on how to establish the counterfactual baseline and demonstrate that projects are "additional" (Carter 1997; Baumert 1999; Sugiyama and Michaelowa 2001; Bode and Michaelowa 2003; Greiner and Michaelowa 2003; Dutschke and Michaelowa 2006). Already at this stage it was noted that the characteristics of the CDM, including the need for demonstrating additionality, might generate perverse incentives for developing countries (e.g. Bode 2005).

2.3 Incentives generated by the CDM

2.3.1 A framework for analysis

The literature summarized above has provided an overview of the general incentives existing for cooperation in the management of an international public goods problem, and the characteristics of the policy choices that have been taken to address the problem of climate change internationally.

The CDM as an international offset mechanism has however unique characteristics that make it generate unexpected incentives that affect the willingness of developing countries to engage in further mitigation action. Due to the novelty of the CDM, the literature dealing with these incentives is relatively limited and mainly based on analysis of the observed performance of the mechanism.

However, the policy analysis literature can be helpful in systematizing and analysing this aspect of the CDM. Policy analysis can be defined as 'a process of multidisciplinary inquiry designed to create, critically assess, and communicate information that is useful in understanding and improving policies' (Dunn 2004, p. 2). It is thus problem-oriented and pragmatic. One of the schools of thought within policy analysis seeks to explain the results and effects of public action, both in terms of the realization of their objectives and of the appearance of unintended or undesirable effects (Knoepfel et al. 2007). The perverse incentives generated by the CDM as an international public policy can be analysed in these terms.

The analysis of policies and international regimes considers three levels of effectiveness of institutions. At the output level, the actual rule-making and negotiation behaviour is analysed. At the outcome level, the implementation of the rules and the resulting behavioural change of the involved actors are assessed. Finally, at the impact level, the real contribution to the ultimate target of the policy or regime is evaluated (Easton 1965; Underdal 2004; Young 2004). Due to the interrelatedness of policies from different issue areas and their overall complexity, policies may often result in unintended consequences (Dunn 2004). Unintended effects of policies are not necessarily undesirable (Merton 1936). They can involve positive unexpected benefits (windfalls) or negative unexpected effects (perverse results or incentives).

For the CDM case, the sets of rules, methodologies, procedures for implementation and the decision-making processes leading to them could be considered the outputs. The actual CDM projects; their quality, functioning and distribution; the appearance of new actors involved in designing, assessing and approving these projects and their functioning; and the participation of countries in the system would be some outcomes of the policy. Finally, the environmental effectiveness – the amount of real reductions in greenhouse gas emissions – and the contribution to sustainable development in the host country would be the main impacts. In addition, there are feedbacks between these three levels. The current incentives and performance of the CDM in terms of project quality, type and distribution and especially environmental effectiveness will have an important role in the decision-making towards a new (or reformed) climate agreement (future output). These incentives and their relation to decisions about a new (or reformed) climate agreement are the focus of this dissertation, and due to the fact that they were mostly not foreseen by the policy-makers designing the CDM, they can be considered as unintended consequences that this instrument may have on the participation of its host countries in a future climate regime.

2.3.2 Unintended consequences

2.3.2.1 Positive incentives

This section describes how the CDM can have positive incentives towards climate change mitigation in developing countries.

The CDM can have a positive long-term effect on broader technological paths and on the evolution of the energy systems of developing countries towards a more sustainable, diversified system, which could be considered a contribution of the CDM towards environmental effectiveness (GHG emission reductions) in a long-term perspective. It can be argued that more advanced developing countries should use more effective means of achieving such broad transformation of the energy system, because the project-by-project nature of the CDM is too limited in scope (e.g. Figueres and Newcombe 2007), and because these countries may already be capable of adopting sectoral or national emission reduction actions (or targets). However, poorer countries with smaller economies, in particular Least Developed Countries, still need a substantial amount of external support for achieving such transformation.

Especially as economies in poor countries still need to develop and infrastructure – including in the energy sector – still needs to be constructed, there is a window of opportunity for cleaner technologies to be used in achieving this development. The window of opportunity concept, derived from the evolutionary innovation economics (see e.g. Dosi (1982) or Nelson and Winter (1982)) 'is based on the observation that, owing to lock-in effects, the diffusion of new technologies, particularly in the field of major technologies and the framework of technological trajectories, is scarcely possible. A window of opportunity only opens if the existing technology development system becomes unstable and thus allows for new technologies to hit the market' (Rennings 2007, p. 21). While in more developed economies this may happen whenever the dominant technology needs to be replaced or expanded (reinvestment cycles), in LDCs the technology still needs to be established in the first place.

From a theoretical view, it is generally argued that the changes brought about by the CDM are used to offset emissions generated in industrialized countries, so that these changes should not be counted towards a reduction of GHG emissions in the host countries. A possible counter argument could be that CERs for CDM projects are issued only up to a maximum of 21 years, while capital investments could last longer, so that the reductions achieved after the crediting period could be counted towards the host country's own reductions. Another counter argument is related to the window of opportunity concept explained above: if the CDM can contribute to fostering investment in clean technologies in LDCs (and using the window of opportunity), it will thus contribute to a lower long-term emissions path.

A second potential positive incentive of the CDM towards mitigation relies on the fact that it contributes to covering the incremental costs of clean technologies (in comparison with traditional, more emissions intensive ones). If the CDM can help to cover the incremental costs of technologies that are still not mature, helping to induce learning effects and cost reductions, then it might generate positive spillover effects beyond the individual CDM projects.

Technological innovation is a process over time, covering from research and development to invention, to the first commercial application, to the diffusion of the technology by means of the market. But it is not a linear process; it rather has complex feedbacks: The transition between the three stages is not automatic; technologies may fail along the process; further progress in research and development might affect products already in the market; learning from products already in use can have an impact on research and new innovations (Stern 2007).

These learning effects and other dynamic increasing returns, such as economies of scale, can arise throughout the diffusion of the technology, and lead to diminishing costs of its production and use. These diminishing costs are usually reflected in experience curves (for a recent example of the application of experience curves to renewable energy technologies, see Junginger (2005)). New technologies may not become cost effective until significant investment has been made and experience developed. In some sectors, as in power generation, this may mean decades of time and very high costs. Public policies are thus needed to support the diffusion of such immature technologies. The CDM, by financially supporting such diffusion (by itself or coupled with other supportive policies) may thus contribute to long-term learning effects and cost reductions that make the clean technologies competitive in an earlier moment (Stern 2007).

This section has described two potential positive incentives of the CDM, one related to the window of opportunity to achieving a cleaner energy system in LDCs, and the other one related to the possibility to contribute to long-term cost reductions of immature clean technologies. The empirical analyses in Chapters 3 and 4 relate to the first of these positive incentives, by looking at the effectiveness of proposals that have been made to improve the participation of LDCs in the CDM. The analysis in Chapter 6, by looking at why the CDM portfolio includes expensive emission reduction options, seeks to provide insights into the second of these positive incentives.

2.3.2.2 Perverse incentives

Within the existing literature on the performance of the CDM, I have identified five potential perverse incentives that may be generated by this instrument, which can be summarized in three types of effects, as shown in Table 2.1. These five perverse incentives are described in the following paragraphs.

A first way in which the CDM generates disincentives for action is the 'paradox of participation' described by Gupta et al. (Gupta et al. 2007b, p. 409), which relies on effects of the balance between supply and demand for carbon credits: the more CDM projects are developed and generate credits, the lower will be the price for such credits, given a fixed demand for carbon credits (which is determined by the emission reduction targets of Annex I countries and their domestic policies to reduce emissions). This, in turn, may affect the financial feasibility of the projects, in case they require the CDM income for assuring such feasibility (which should be the case for "additional" projects).

Table 2.1: Perverse incentives characterizing the CDM and their potential effects

Perverse incentive	Potential effect
Paradox of participation	Affecting the amount of emission reductions achieved through the CDM
Asymmetric nature of the CDM	
Trade-off between CDM additionality and domestic policies	Affecting potential mitigation through own climate-friendly policies in developing countries
The CDM as a financial transfer instrument	Affecting the willingness of CDM host countries to adopt future emission reduction targets
The fear that the CDM might exhaust cheap emission reduction options	

Source: Own elaboration on the basis of the literature review below.

Secondly, the CDM has an asymmetric nature, which means that it rewards emission reductions but does not penalize emission increases, thus working as a subsidy to emission reductions. If the price of emission reductions is much higher than the abatement costs, such a subsidy may create the perverse incentive to invest in emissions intensive activities first, so that credits can be earned later for reducing their emissions (Burniaux et al. 2009). There are fears that such perverse incentives may affect projects that reduce the emissions of industrial gases. Projects that reduce the emissions of the greenhouse gas HFC-23 from facilities manufacturing the refrigerant HFCF-22 are an example: as HFC-23 is a very potent GHG, revenues accruing from the sale of CERs in projects reducing such emissions may even be higher than revenues from the sale of the plant's HFCF-22 production (Wara 2008). Due to concerns that this could result in the installation of new manufacturing facilities solely for the purpose of earning CERs, CDM projects are so far not allowed in new HFCF-22 facilities. On top of this, there are concerns that individual installations may be increasing production artificially in order to earn more CERs (CDM Methodology Panel 2010; Schneider et al. 2010; Schneider 2011).

Thirdly, as will be discussed in more detail in Chapters 5 and 6, the CDM has also created moral hazard problems for developing country governments, which may be discouraged by the CDM additionality rule from enacting policies that contribute to reducing emissions (Hepburn 2007). To avoid this perverse incentive, the CDM authorities adopted the E+/E- rule in November 2005, which states that climate-friendly policies passed after the year 2001 are not to be counted towards the additionality constraint of CDM projects. Since this rule was adopted, developing countries have been allowed to combine new domestic policies that support climate friendly investments with the CDM subsidy, up until 2009, where debate on this issue started again in the case of Chinese wind energy projects (He and Morse 2010).

Fourthly, besides being a mechanism that improves the "where" flexibility of the carbon market established by the Kyoto Protocol, the CDM is also a financial transfer from industrialized to developing countries that provides a subsidy to emission reduction projects. As a result, the mere existence of the CDM and the opportunity to receive financial transfers from it means that those actors benefitting from it (both private and government actors in CDM host countries and in countries that wish to host CDM projects in the future) will be interested in maintaining such transfers in the future. This means that the CDM itself may discourage its host countries from taking a step further in climate change mitigation and, for example, adopting own emission reduction targets (Wara and Victor 2008; Burniaux et al. 2009; Hagem and Holtsmark 2009).

The extent to which this happens depends on how much the country is profiting from the CDM, on the price difference between CDM emission reduction credits and emission allowances from countries with reduction targets, and on how stringent the emission reduction target is. If a country adopts a very lenient target that can be met by applying policies it had anyways envisaged to adopt, then it may easily achieve a surplus of allowances, which can be sold in the international carbon market at a price that is usually higher than the CDM credit price (CDM credit prices are negatively affected by performance and delivery risks that arise because credits are only issued ex-post, after the emission reductions have taken place). The importance of this effect is that, while the CDM has been conceived as a transitional mechanism for developing countries to prepare for adopting mitigation commitments in the future (Hepburn 2007), it itself may undermine this goal.

Given the already existing unwillingness of developing countries to adopt emission reduction targets discussed above, and the postulated need to encourage them to do so through, e.g. side payments, the effect of the CDM is that, in addition, developing countries will also need to be compensated for the benefits they will potentially lose from no longer being able to participate in the CDM once they adopt emission reduction targets.

Fifthly, CDM project opportunities have been characterized as exhaustible resources (Rose et al. 1999): developing countries fear that participating in the CDM will exhaust the cheap emission reduction opportunities and leave them only with more expensive reduction options for compliance with future reduction targets. While the strength of this argument is limited, due to the characteristics of the carbon market (see e.g. Akita 2003; Germain et al. 2007; Narain and van't Veld 2008; as well as Chapter 5 of this dissertation), it has repeatedly been used in the climate change negotiations. Hence, the potential trade-off between present rents from the CDM and future low cost abatement opportunities is another source of disincentives for CDM host countries to adopt emission reduction targets.

The theory so far says that the CDM may in many ways discourage climate change mitigation in developing countries: by affecting the amount of emission reductions that the CDM itself may generate, by preventing developing country governments from adopting domestic climate friendly policies that contribute to reduce emissions (even in the absence of emission reduction targets), and by discouraging developing countries from adopting emission reduction targets. While a more detailed analysis of all of these types of perverse incentives is out of the scope of this dissertation, the empirical analysis in Chapter 5 will look deeper into the one described in the fifth place, and analyse whether such the CDM has so far exhausted an important share of the cheap emission reduction opportunities in some of its main host countries (see Figure 1.2).

3. WOULD PREFERENTIAL ACCESS MEASURES BE SUFFICIENT TO OVERCOME CURRENT BARRIERS TO CDM PROJECTS IN LEAST DEVELOPED COUNTRIES?[9]

3.1 Introduction

As described in the introductory chapter, the CDM has been an overall success in terms of the amount of projects and the projected emission reductions that have been mobilized. However, its project portfolio is very unevenly distributed across host countries. China, India and Brazil account for about 73% of all projects in the pipeline and 76% of expected annual CERs. Least Developed Countries (LDCs) host just 68 CDM projects in the pipeline (1.2%), out of which only 23 projects are registered (UNEP Risoe Centre 2011a).

This uneven distribution of the CDM has been repeatedly criticized, as it directly affects both countries' expectations of receiving CDM-related financial flows, and the realization of the second goal of this mechanism, which is to contribute to sustainable development in its host countries. Several studies have discussed the impact of this distribution on equity, efficiency and environmental considerations (Cosbey et al. 2005; Keller 2008).

The Marrakech Accords that specify the detailed rules of the mechanisms under the Kyoto Protocol emphasize the importance of an equitable geographical distribution of CDM projects across countries and regions (UNFCCC 2001b). Thus, already in 2001, the Conference of the Parties to the UNFCCC called for the CDM Executive Board (EB) to report 'to the COP/MOP on the regional and subregional distribution of CDM project activities with a view to identifying systematic or systemic barriers to their equitable distribution' (UNFCCC 2001b, p. 28). The COP/MOP confirmed this at its first meeting in 2005, asking the EB also to suggest options to address these barriers, and to broaden participation in the CDM (UNFCCC 2005c, p. 98). The Copenhagen conference in 2009 decided that simplified procedures for demonstrating the additionality of very small projects would be introduced, payment of registration fees would be postponed and upfront financing for CDM project validation and registration would be provided for projects in hitherto underrepresented countries (UNFCCC 2009).

---

[9] This chapter is largely based on following article: Castro, P. and Michaelowa, A. (2011), 'Would preferential access measures be sufficient to overcome current barriers to CDM projects in least developed countries?', *Climate and Development* , vol. 3, no. 2, pp. 123-142.

Also, for the period after 2012, the EU – currently the main market for CERs – has established special import quotas for CERs from LDCs or Small Island Developing States (SIDSs). Additionally, in the case that no new international agreement on climate change mitigation is reached, specific qualitative restrictions on CERs will apply, some of them specifically favouring LDCs over other CDM host countries, as will be discussed in section 3.3.2.

Another specific measure taken with the aim of addressing the high transaction costs of the CDM, especially for small-scale activities that can be replicated many times, was the introduction of Programmes of Activities (PoAs)[10] in 2007. While not specially designed to improve the participation of LDCs in the CDM, it is believed and expected that the types of activities suitable for PoAs are more in accordance to the needs of LDCs than the activities typical in larger-scale CDM projects (Figueres and Newcombe 2007).

Analysts are also discussing other ways of differentiating countries in the CDM. Proposed means include: differentiated eligibility of CDM host countries, discounting of emission reduction credits from different host countries, introducing a cap to the amount of emission credits that can be issued from projects in each country, and a more directed allocation of demand towards particular host countries (Bakker et al. 2009; Castro and Michaelowa 2010).

While all these proposals to improve the geographical distribution of CDM projects are on the table, and in particular measures for granting preferential access to CERs from LDCs are already being implemented, there is very limited research on whether these proposed solutions will have the desired effect.

The following questions thus arise: Could preferential access measures such as the ones described above really improve the participation of LDCs in the CDM? Can new modalities of CDM projects, such as the PoAs, which aim to target more distributed emission sources, provide a contribution? What are the general risks of preferential access measures?

This chapter seeks to address this gap in research by developing a general market model for CDM emission reduction credits supply and demand under different post-2012 climate policy scenarios, which reflect the preferential access measures described above. Its main methodological contribution relies in a new approach for estimating CER supply from the CDM portfolio, which is more accurate than a direct aggregation of the existing portfolio, as it incorporates the effects of failing to achieve registration at the different stages of the CDM project cycle. This supply is contrasted with the projected demand for CERs from industrialized countries after 2012, which is based on official emission projections and plausible assumptions about the stringency of emission reduction targets

[10] Programmes of Activities are a modality of CDM projects, which allows for bundling similar activities taking place in different locations into one single project. Their aim is to simplify access to the CDM to emission reduction activities that are dispersed in nature and can begin in different points in time, such as the distribution of efficient cooking stoves, or the installation of micro hydro power stations.

they will adopt for the period 2013-2020.[11] In terms of the general goals of the dissertation, the main contribution of this chapter is an empirical exploration of the potential ability of preferential access measures to improve CDM activity in LDCs.

We start by discussing the current and potential supply of the CDM in LDCs, and presenting an overview of the barriers limiting CDM development in poor countries. In section 3.3, we describe the proposals in the international climate negotiations and in the EU climate and energy package to promote CER supply from LDCs and underrepresented CDM host countries. Section 3.4 develops possible CER supply and demand scenarios for the period 2013-2020. For estimating the supply, we use an extrapolation of the figures provided by the UNEP Risoe Center CDM Pipeline on the current CER supply, corrected for the project approval and credit issuance rates, and assuming different post-2012 regulatory scenarios. For the demand, we project the baseline emissions of developed countries until 2020 and assume a range of likely emission reduction targets and of supplementarity in the use of CDM credits. In section 3.6 we assess the impact of preferential access policies on CER supply from LDCs, and the potential sustainable development benefits from CDM projects and PoAs in LDCs. In section 3.6 we draw a comparison between a preferential access agreement in the agricultural trade system and the climate regime, before concluding in section 3.7.

3.2 The CDM in LDCs

3.2.1 Current and potential supply of CDM projects from LDCs

As described above, LDCs currently host about 1.2% of the CDM projects in the pipeline. In terms of volume of credits, they are expected to generate just around 0.5% of all CERs projected by 2012 (UNEP Risoe Centre 2011a). The foreseeable short-term CER supply from LDCs, including projects that are in the pipeline and project ideas mentioned in country-specific studies or CDM promotion websites (Chea 2006; Uprety 2006; Waste Concern 2006; Ministry of Water and Environment, Republic of Yemen 2008), amounts to about 115 million CERs over the whole lifetime of the projects. This supply is dwarfed by the potential in just China, India and Brazil, which will reach about 6.7 billion CERs by 2020.

However, a recent World Bank study on the abatement potential in the energy sector in Sub-Saharan Africa (De Gouvello et al. 2008) estimated a potential of about 4 billion CERs from Sub-Saharan LDCs over a project lifetime of 10-21 years. The study used existing CDM methodologies to identify technologies that could both promote GHG emission reductions and support energy supply in the region. It made a bottom-up inventory of over 3200 potentially feasible clean energy projects applying 22 technologies in 44 countries in Sub-Saharan Africa. Comparing this theoretical potential

[11] Note that both the supply and the demand scenarios presented in this chapter were developed before the Copenhagen meeting took place, so that the assumptions made here relate to the situation in the international negotiations during that time – this is, many industrialized countries had not yet announced their emission reduction pledges for the post-2012 period.

with the real number of CDM projects from these countries gives an idea of the scale of the barriers for implementation the LDCs face.

The emergence of the Programmes of Activities (PoAs), bundles of decentralized projects (Component Project Activities or CPAs) within the umbrella of one individual CDM *programme*, could provide an inroad for the type of small-scale projects that are expected to be most likely hosted by LDCs. When in June 2007 the CDM Executive Board agreed on rules for PoAs, it was hoped that they would significantly reduce transaction costs and mobilize the diffusion of small technologies, where the exact number and location of projects would not be known ex ante. However, for over two years, PoAs did not really move forward. The main reasons were regulatory barriers, such as the liability of the project validator for any part of the PoA that might be found faulty even years after its registration, the limitation to one baseline methodology and the debundling rules for application of small-scale methodologies. The liability requirement in particular led validators to refuse to validate PoAs. After a long regulatory tug of war, the EB removed most of the barriers in May 2009. Moreover, validators now shift the liability to the PoA developer through a private law contract. Nevertheless, even after the May decision, PoAs only moved slowly – until December 2009, when submissions actually exploded. As of January 2011, 77 PoAs have been submitted for validation, and 6 have been registered (UNEP Risoe Centre 2011a).

The distribution of PoAs among host countries differs considerably from standard CDM projects. The large players are comparatively underrepresented, whereas countries that have set up good CDM institutions such as Bangladesh, Indonesia and Vietnam have several PoAs. LDCs have a share of 10.4% of projects compared to about 1% in the normal CDM pipeline.

3.2.2 Barriers

What are the reasons for the marginal involvement of LDCs in the CDM? Mitigation potential, institutional CDM capacity and the general investment climate have been used as predictors of attractiveness of host countries for CDM projects, with the finding that about 74% of LDCs are very unattractive, 24% have limited attractiveness, and only 1% are attractive for CDM projects outside of the forestry sector (Jung 2006). Several econometric studies have confirmed these expectations (Dolšak and Crandall 2007; Flues 2010; Winkelman and Moore 2011). Three arguments may be at play here. On the one hand, income and growth are indicators of the availability of domestic resources to finance CDM investments. On the other, growth, but also population size, carbon intensity and other general indicators of the size of the economy indicate the existence of emission reduction opportunities (mitigation potential). Finally, good macroeconomic indicators encourage foreign investors to enter these attractive markets, which is relevant for the case of bilateral CDM projects. For such bilateral CDM projects, in addition, the existence of past bilateral relationships (such as high trade volumes, bilateral aid or past colonial ties) also helps to explain the projects' geographical distribution, as found by Dolšak (2007). More radically, in a recent working paper, Lütken (2011) shows that defining what is "equitable" in terms of CDM project distribution depends strongly on how this distribution is measured. He argues that attempts to qualify the geographic distribution of the CDM need to take into account circumstances that make certain countries highly unlikely to host CDM projects, such as on-going armed conflicts, or very small size as in several small island states. In addition, he shows that when measuring CDM project distribution in different ways (e.g. in terms of number of projects per level of national CO_2 emissions or per GDP level), very different pictures may be drawn. For example, if the number of expected CERs is compared to the current national CO_2 emission level, then LDCs on average outperform all other regions analysed in Lütken's study. Similarly, Flues (2010) discusses that, comparing across otherwise similar countries, a 1% increase in population on average leads to a 1% increase in the number of projects hosted.

More specific barriers for CDM implementation in LDCs, especially in Sub-Saharan Africa, have been thoroughly discussed within the Nairobi Framework. This initiative was launched at COP/MOP2 in Nairobi (2006), with the aim of helping these countries to improve their level of participation in the CDM. This initiative was useful for launching a discussion of the specific barriers that hinder CDM project implementation in these countries, particularly in Sub-Saharan Africa (for further details, see Muyungi 2006; Agyemang-Bonsu 2007; UNEP 2007; World Bank 2007; Kinkead 2007; Ellis and Kamel 2007).

Following Ellis and Kamel (2007), Michaelowa (2003) and Silayan (2005), important general characteristics of successful CDM host countries are:

- An enabling business environment: stable and transparent general institutional framework, stable and predictable investment laws
- The existence of relevant financial incentives, such as tax reductions for renewable energies, import tariff reductions for CDM technology, etc.
- Reduced ownership restrictions for foreigners
- Undistorted energy pricing policies
- Local technical capacity and awareness of the CDM as a project financing option
- Availability of underlying project finance, especially through local financial capacity
- Availability of CDM project options that are sufficiently large to compensate for the CDM transaction costs; this is coupled to the country's emissions mitigation potential
- Ability to minimize other country or project-related risks that may render the performance of the project uncertain
- Existence of historical business or aid relationship with emissions credit buyers (Dolšak and Crandall 2007).

CDM-specific characteristics are:

- Existence of CDM-related institutions: Kyoto Protocol ratification and establishment of an operational national CDM approval authority
- Clear, capable and effective CDM policy framework: clear rules for national approval, timely and simple procedures, low national transaction costs, experience and continuity of national approval staff
- Existence of CDM promotion offices
- CDM awareness in government, industry, consultants and financial intermediaries

- Existence of baseline data for project design
- Existence of applicable CDM methodologies for the desired project type
- No constraints on eligibility of potential project types – for example by the EU ETS or other major credit buyers, or due to temporary nature of credits (in the case of forestry projects)
- Capacity of auditing companies (validators or 'Designated Operational Entities') in the relevant region.

One of the barriers most frequently mentioned is the limited institutional and technical capacity to develop and implement CDM projects. In the public sector, it is not only the Designated National Authorities (DNAs) for the CDM that need to be established and have a minimum budget, but also the institutional framework for the sectors involved in the project (e.g. energy) is crucial. In the private sector, the presence of trained national CDM consultants is essential for coping with the complex CDM rules at affordable costs. The limited access to financing is an equally important barrier. On the one hand, domestic financial institutions lack capacity and awareness of the CDM as an investment option. On the other, the unattractive investment climate in these countries discourages foreign investors. Indeed, the CDM mainly functions as an additional revenue source for companies that already have financing. Annex I countries and companies are investing in CDM projects only in countries where they are already present (e.g. through subsidiary electricity companies), where they see a market for their products, and where stability is guaranteed (Lütken and Michaelowa 2008).

There are few possibilities to develop large CDM projects in LDCs, as the energy demand and industry are still small in these countries.[12] In Africa, the largest emission reduction potential lies in sectors that are not significant in the CDM at present (forestry, agriculture, reducing the use of non-renewable biomass). As many countries already rely heavily on hydroelectric power, their baseline grid emissions are low. This makes grid-connected renewable energy and energy efficiency projects less viable, as their potential to earn CERs is reduced. However, while many observers assumed that small projects were not viable through the CDM due to the high transaction costs (Michaelowa and Jotzo 2005), nowadays there is a noteworthy amount of very small CDM projects and a substantially higher amount of very small CPAs in the pipeline (see Figure 3.1), which suggests that the transaction cost barrier can be overcome.

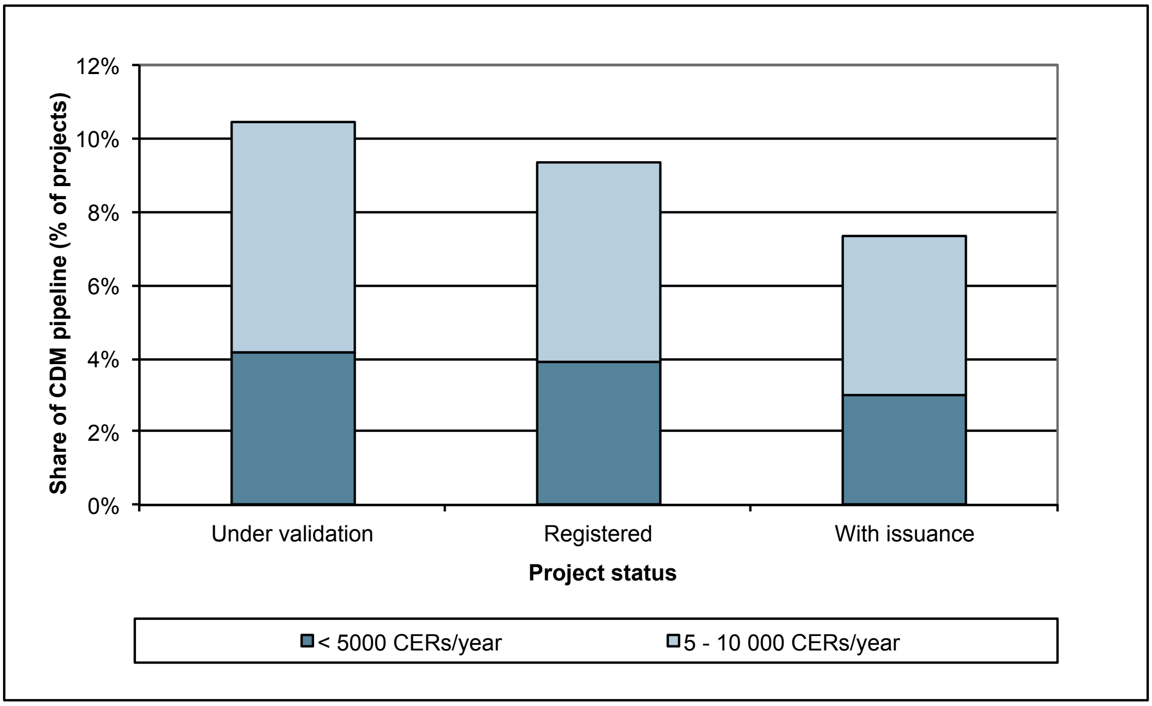
Another important barrier is the availability of data for baselines and monitoring: gathering this information is too costly for just one or two projects. Hence, in countries where the emission reduction potential is low, nobody makes this effort. Finally, the lack of infrastructure (roads, large equipment but also laboratories for calibrating measurement devices) is another limiting factor for the CDM in LDCs.

---

[12] Poverty and lack of infrastructure reduce the demand for energy services in poor countries: energy use would be higher if people could afford it or the infrastructure was in place. Depending on whether this suppressed demand is taken into account or not, baselines for CDM projects may change significantly (for a discussion of the issue see Winkler and Thorne 2002).

It is however possible to overcome these barriers, as the case of Honduras shows. Honduras is not a LDC, but a small and poor country, with an unstable political regime and unattractive investment climate. Corruption and crime are high, access to finance difficult. Despite substantial CDM capacity building and financial support for establishing a functional DNA, staff replacement after changes of government has led to losses in institutional capabilities. As most of its electricity is produced from fossil sources, Honduras has some mitigation potential from renewable energy. Additionally, Honduras was an early mover in the privatization of the electricity sector in Central America, and financial incentives for renewable energy are in place. However, its electricity system is highly inefficient, and prices can only be sustained due to subsidies (Figueres 2002; Keller 2008; Lokey 2009). Nevertheless, Honduras hosts 30 active CDM projects, 16 of which are registered (UNEP Risoe Centre 2011a). Honduras has apparently benefited from the leadership of a strong group of entrepreneurs in the renewable sector, who initiated all the CDM projects and created an association that allowed them to pool and share their experience. There is also a local CDM consultancy and a couple of international ones with a presence in the country (Keller 2008; Lokey 2009). This domestic leadership, coupled with the early support from international donors, may be the key for the success of Honduras in the CDM.

Figure 3.1: Share of very small projects in CDM pipeline (%)



Source: UNEP Risoe Centre (2011a).

3.3 Preferential access measures in the climate regime

3.3.1 In the international climate negotiations

As mentioned in the introductory chapter, several measures to improve the regional distribution of CDM projects have been discussed in the international climate negotiations. However, the negotiations at COP 15 in Copenhagen proved a roller-coaster ride for LDC interests. The initial text proposed a subsidy for development of the CDM project documentation (Project Design Document or PDD) and for validation of projects in LDCs with less than 10 registered projects. A second text version referred to 'less developed' countries, without specifying what countries were referred to. But the final text just kept the reference to countries with less than 10 registered projects, without limiting the subsidy to any group of countries, so that now even rich Middle Eastern oil-exporting countries qualify. Moreover, the initially foreseen grant mutated into a loan that would have to be repaid upon the first issuance of CERs, and the total volume of the fund is capped at the interest accruing on the surplus funds of the EB, which will limit it to 1-2 million US$ per year. On a positive note, the COP decision also states that grid emission factor calculations in LDCs should be more flexible[13] and that suppressed demand will be taken into account in baselines (UNFCCC 2009).[14] It remains to be seen, however, what impact these provisions will have on actual project implementation.

3.3.2 In the EU climate and energy package

In the European Climate and Energy Package for 2013-2020, the EU has committed itself to reducing its overall emissions to at least 20% below 1990 levels by 2020, and to 30% below 1990 if a new global climate change agreement with comparable efforts by other developed countries is reached (European Parliament 2009a; European Parliament 2009b). It imposes new limits on the amount of CERs from CDM projects and ERUs (Emission Reduction Units) from JI projects that will be allowed to be imported into the EU between 2008 and 2020. Different provisions apply for the EU Emissions Trading System (EU ETS), which covers the electricity generation sector and all heavy industries (iron and steel, cement, oil refining, glass, lime, bricks, ceramics, and pulp and paper), amounting to about half of the EU-27's CO_2 emissions (European Commission 2010), and for the sectors outside the ETS (so-called non-trading sectors), such as households and agriculture. Assuming that the EU ETS credit imports would be distributed linearly along all years in the period 2008-2020, Table 3.1 presents the potential CDM/JI credit demand from the EU for the period 2013-2020, in the scenarios with and without an international agreement.

---

[13] Grid emission factors are used in the CDM to estimate the baseline GHG emissions from the production of electricity in each land or region. This information is then used to calculate how much abatement a project in the electricity sector generates. The calculation of grid emission factors requires data from all installations producing electricity in the respective land or region, which poses a barrier especially in LDCs.

[14] For a definition of suppressed demand, see Footnote 12 above.

Table 3.1: Potential credit demand from the EU for the period 2013-2020

Source	20% reduction ($MtCO_2e$)	30% reduction (with international agreement) ($MtCO_2e$)
EU ETS	954	1824
Non-trading sectors	750	1300
TOTAL	1704	3124

The package includes a provision with high relevance for LDCs. For the non-trading sectors, the limit for credit imports under the 20% reduction scenario has been generally set at 3% of the sectors' emissions in 2005. Twelve countries are allowed to import up to 4% of their 2005 emissions.[15] The extra 1% granted to these countries – around 80 million CERs - can be imported only from LDCs or Small Island Developing States (SIDSs) (European Parliament 2009a).

There are some additional conditions for the acceptance of CERs or ERUs in the European system, one of them again particularly relevant for LDCs. While the restrictions on approved project types sought by the Commission (on the basis of a consideration of 'high quality projects') were not approved, forestry credits will still be banned from the EU ETS, but are accepted for the non-trading sectors. Additionally, if no new climate agreement is reached, only the following CERs or ERUs will be accepted:

- Credits issued during 2008-2012
- Credits from projects registered before 2013, but issued later
- CERs from projects registered after 2012 in LDCs
- Credits from projects in countries where a bilateral agreement has been reached with this aim.

Thus, in the case that no international agreement is reached, the EU is very clearly attempting to direct its demand for carbon credits towards LDCs. In the case that a new international climate agreement is reached, such restrictions do not apply, but from 2013 onwards the EU will accept credits only from countries that have ratified this agreement (European Parliament 2009b).

The original EU agreement provided for the possibility to add further qualitative criteria restricting the acceptance of credits in the EU system from 2013 onwards. Criteria discussed at the time included accepting only renewable energy and energy efficiency projects, or only 'high quality' projects, which were however not concretely defined. In 2010, a debate emerged about the quality of the emission reductions generated by CDM industrial gas projects. Industrial gas projects reduce the emission of gases with very high global warming potential from industrial facilities – notably the emissions of HFC-23 from the production of refrigerants, and of nitrous oxide from adipic acid and nitric acid production. Although the additionality of these projects was initially not contested (in the absence of related legislation, there is no incentive other than the CDM revenue to implement the

[15] Austria, Belgium, Cyprus, Denmark, Finland, Ireland, Italy, Luxembourg, Portugal, Slovenia, Spain and Sweden.

projects), they have been criticized because the CDM revenue largely exceeds the cost of reducing the emissions and can even exceed the value of the actual feedstock production at the plant (Wara 2008). The CDM may thus provide the perverse incentive of increasing production in order to receive more revenues from the CDM. Criticism increased due to apparent flaws in the baseline methodology for some of these projects, which would allow such perverse incentives to subsist (CDM Methodology Panel 2010; Schneider et al. 2010; Schneider 2011). In response to this debate, in 2011 the EU adopted a ban on the use of CERs from projects that destroy HFC-23 and nitrous oxide from adipic acid production (European Commission 2011).

Since the international negotiations under the Climate Change Convention and the Kyoto Protocol have so far not yielded any new legally binding emission reduction targets for industrialized countries after 2012, the EU climate package is currently the only legally-defined market for CDM projects after 2012. This is why Europe's decisions regarding the CDM are so important for the future of this mechanism.

Some questions remain as to the extent to which these measures can boost CDM development in LDCs: Are other Annex I countries going to match this EU initiative, and to what extent? Will the financial and technical barriers for CDM development in LDCs be overcome through these measures? And even if they are, will LDCs be able to match potential demand with an adequate supply? In the following section, in order to try to answer some of these questions, a few possible post-2012 climate policy and carbon demand scenarios are presented. They will then be matched with our estimations of carbon credit supply from the CDM.

3.4 Post-2012 climate policy and market demand-supply scenarios

In order to assess the effect of possible preferential access for LDCs and other policy scenarios for the future CDM, we create carbon credit demand and supply scenarios with and without an international agreement for the period 2013-2020.

3.4.1 The market for CDM emission reductions credits

The demand and supply scenarios that will be presented below are based on the consideration that the CDM is a market that was initiated by regulation. As a result, both the supply of credits and the demand for them respond to the characteristics of the regulations concerning the CDM.

While the main regulatory body governing the CDM consists of the Kyoto Protocol, subsequent COP/MOP decisions (importantly the Marrakesh Accords), and more specific guidance issued by the CDM EB, the discussion of preferential access measures above demonstrates that also regulations from buyer countries on the acceptability of CERs in their internal emissions trading systems may affect CDM supply and demand.[16]

Under these circumstances, there may be different views about what constitutes the demand for CERs and what constitutes supply. In this chapter, we thus define potential demand for CERs as the difference between projected baseline emission levels and emission reduction targets in buyer (Annex I) countries for the period 2013-2020, accounting additionally for regulations on the amount of CERs allowed to contribute to filling this difference ("supplementarity").[17] CER supply is defined as the projected amount of emission reduction credits that will be issued from CDM projects in the 2013-2020 period, considering the effects of barriers and delays within the CDM project cycle on such issuance, and considering also regulations that establish what kind of CERs are eligible during that period.

3.4.2 Demand scenarios

Three potential CER demand scenarios are defined on the basis of the status of UNFCCC negotiations and pledge announcements as of mid-2009: scenario 1, in which no international agreement on post-2012 emission reduction targets is achieved; scenario 2, in which such an agreement is realized; and scenario 3, in which an agreement is realized but a financial crisis reduces the demand for CERs by slowing down growth and reducing emission levels in Annex I countries.

For the demand scenario with no international agreement, we take the announced 20% reduction for the EU, and the greenhouse gas reduction targets announced by other Annex I governments till mid-2009 that are not contingent on an international agreement. For countries that by that time had not made any announcements on reduction targets, we assume plausible ones. For the scenario with an international agreement, we take the 30% target for the EU and tighter targets for other Annex I governments, which we expected could be agreed during the negotiations. The scenario with financial crisis presupposed that an international agreement is reached, thus taking the same targets as scenario 2, but it assumes that the baseline emissions in Annex I countries will be lower than in the base case during the first two years due to the effects of the financial crisis. Table 3.2 presents the concrete assumptions of the original demand scenarios.

To estimate emission demand in the described scenarios, the baseline emission levels of Annex I countries[18] are taken from projections from the EU climate package described above; European

---

[16] Also regulations of CDM host countries can affect supply, for example by defining the characteristics of the projects that are acceptable in the national context (sustainability criteria). This aspect is however not analysed here, as there is no evidence so far that CDM host countries have been keen on adopting such restrictions for CDM projects.

[17] The Kyoto Protocol established that using of CERs from CDM projects to meet Annex I countries' emission reduction targets has to be supplementary to domestic action. However it was never defined how much domestic action should be done, and how large would the CDM contribution be allowed to be. This definition is thus de facto left to each individual Annex I party.

[18] Baseline emission levels are those that are expected to happen in the absence of emission reduction targets, but considering the effect of other climate-friendly policies and measures that countries have already adopted or envisage to adopt for reasons other than meeting those targets. Official figures exist for many Annex I countries, as they use them to

Environmental Agency (EEA) projections for non-EU European countries (EEA 2005); energy-related CO_2 emissions from the Energy Information Administration (EIA) of the US Department of Energy and extrapolations of UNFCCC inventories for forestry and non-CO_2 emissions for the USA, Canada and Russia (UNFCCC 2008b; US EIA 2008a; US EIA 2008b); projections from the Australian Government (2008) for Australia; and extrapolations of UNFCCC emissions inventories for the years 2000-2005 for other countries (UNFCCC 2008b).

In the EU-27 case, we assume that CERs are required to be supplementary to domestic emissions reductions, as this group has already announced that only 50% of the effort may be covered by CDM emissions credits. All other countries have not yet defined whether and how they will define supplementarity. For them, we assume that a range between 50% and 100% of the required reductions could be covered through the CDM. We choose, where available (Australia and other European countries), the low emissions path projections, which also account for some domestic mitigation action. The resulting demand scenarios are shown in Figure 3.2 to Figure 3.4.

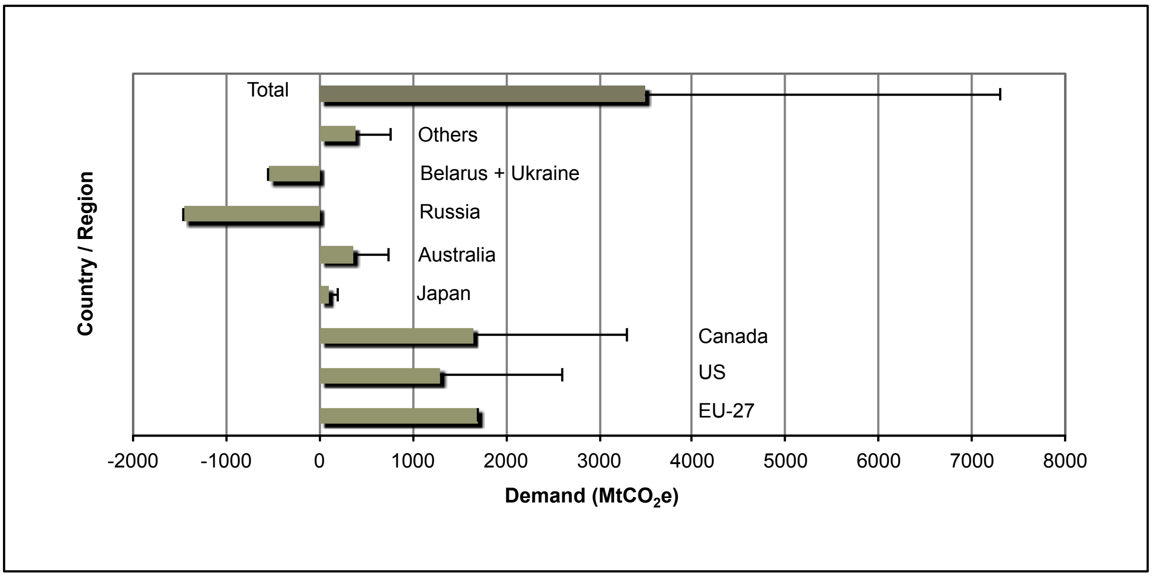
Table 3.2: Carbon credit demand scenarios 2013-2020: assumed emission reduction targets

<table>
<tr><th>Country / Group</th><th>Scenario 1: No agreement</th><th>Scenario 2: International agreement</th><th>Scenario 3: Financial crisis</th></tr>
<tr><td>EU-27</td><td>20% below 1990, credit import up to 50% of reduction effort</td><td>30% below 1990, credit import up to 50% of reduction effort</td><td rowspan="8">Same as in Scenario 2, but baseline emissions during first two years are 3% less than in the base case</td></tr>
<tr><td>US</td><td>Back to 1990 emission levels</td><td>10% below 1990 levels</td></tr>
<tr><td>Canada</td><td>Back to 1990 emission levels</td><td>10% below 1990 levels</td></tr>
<tr><td>Japan</td><td>10% below 1990 levels</td><td>20% below 1990 levels</td></tr>
<tr><td>Australia</td><td>5% below 2000 levels</td><td>15% below 2000 levels</td></tr>
<tr><td>Russia</td><td>20% below 1990 levels</td><td>30% below 1990 levels</td></tr>
<tr><td>Belarus and Ukraine</td><td>20% below 1990 levels</td><td>30% below 1990 levels</td></tr>
<tr><td>Other Annex I</td><td>20% below 1990 levels (including Turkey with 5% below 2012 levels)</td><td>30% below 1990 levels (including Turkey with 10% below 2012 levels)</td></tr>
</table>

Note: During the Copenhagen meeting and in the Copenhagen Accords, some of these pledges were restructured or strengthened. However, the new pledges are non-binding and most of them are also conditional on, e.g., a legally-binding agreement. Thus, the reduction levels assumed here are still realistic.

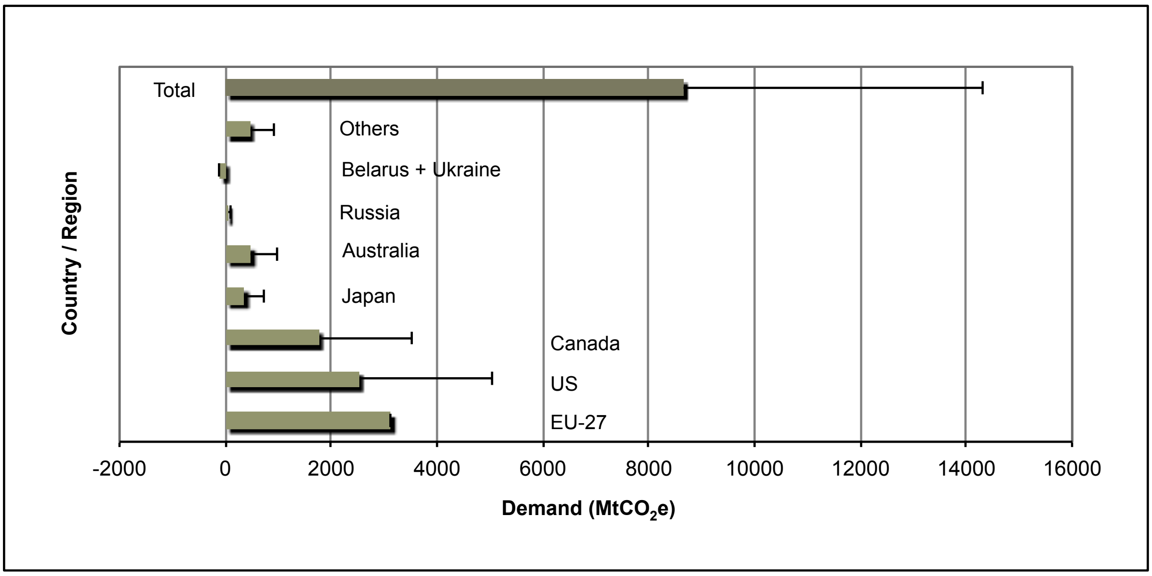
project the level of effort that will be required to meet their targets or pledges. We take these official figures wherever possible.

Figure 3.2: Carbon credit demand 2013-2020 for the "no agreement" scenario



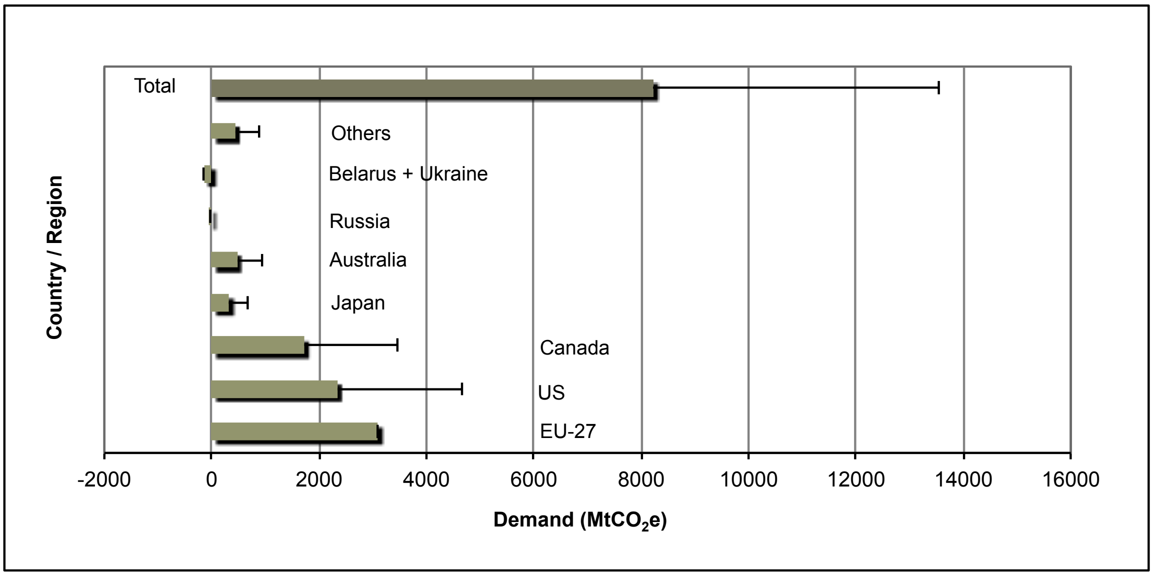
Note: The main bars indicate demand when countries are only allowed to cover up to 50% of their emission reductions through the use of CDM credits; the 'error bars' show demand when there is freedom to use the CDM for offsetting as much as desired. As the EU has already established by law that only 50% of emission reductions can be covered by the CDM, no 'error bar' exists in this case.

Figure 3.3: Carbon credit demand 2013-2020 for the "international agreement" scenario



Note: The main bars indicate demand when countries are only allowed to cover up to 50% of their emission reductions through the use of CDM credits; the 'error bars' show demand when there is freedom to use the CDM for offsetting as much as desired. As the EU has already established by law that only 50% of emission reductions can be covered by the CDM, no 'error bar' exists in this case.

Figure 3.4: Carbon credit demand 2013-2020 for the "financial crisis" scenario



Note: The main bars indicate demand when countries are only allowed to cover up to 50% of their emission reductions through the use of CDM credits; the 'error bars' show demand when there is freedom to use the CDM for offsetting as much as desired. As the EU has already established by law that only 50% of emission reductions can be covered by the CDM, no 'error bar' exists in this case.

Figures 3.2 to 3.4 show that the demand for CERs will mainly be affected by whether there is an international agreement on climate change mitigation or not (with agreement, demand for CERs is roughly double than with agreement), and by how supplementarity is defined in the Annex I countries outside of the EU (a lax supplementarity rule adds between 65% and 109% more demand for CERs, depending on the scenario). The financial crisis has only a small negative impact on CER demand as compared to the scenario with international agreement.

3.4.3 Supply scenarios

How will CDM project submission develop in the future? As in the past, the start-up of new project types such as supercritical coal power plants, carbon capture and storage (CCS) and forestry could lead to rapid changes in the composition of the inflow. Moreover, the interpretation of additionality by the EB and changes in baseline methodologies can have sudden and massive impacts. Supply would decrease if a project category is suddenly deemed non-additional as happened with cement blending.

Another key influence is the development of post-2012 negotiations, including present Annex I countries pressing for increased mitigation actions by developing countries, and, as outlined above, possible limitations on the import of CERs on the basis of quality considerations.

Due to these manifold influences, it is very difficult to forecast future CER volumes. We deal with these difficulties by proposing seven different supply scenarios that consider potential changes in regulations that may affect the eligibility of different CDM project types (or sources). We additionally attempt to make the projections as realistic as possible, by accounting for the effects of failures in registration and validation and delays during the CDM project cycle.

Besides the inflow of new project types and projects of types that are already in the CDM pipeline, the key parameters influencing supply are the delay of project implementation, non-validation rate of submitted projects, the rejection rate of validated projects and the performance rate of registered projects. We therefore derive our supply scenarios based on the projected 2020 CERs from UNEP Risoe Centre's CDM Pipeline as of end of 2008 (UNEP Risoe Centre 2009), modified in order to account for these parameters. None of the following estimations include the potential supply from Programmes of Activities, since so far there are very few PoAs registered, making projections very uncertain. It should be noted that the resulting projections are based only on extrapolation of the observed amount of projects that have been submitted for validation and registration, accounting for observed trends of submissions and approval rates over time. No economic modelling or equilibrium analysis has been used in deriving the scenarios. Thus, the only way in which we make the demand influence our supply estimations is when we assume some policy-related restrictions to the acceptability of CDM projects.

Equation 3.1 estimates the amount of CERs that will be generated until 2020 from projects that are registered until 2012, by adding up the CERs projected from CDM projects submitted for validation up to 2008, to CERs projected from CDM projects that will be submitted in the following years up to 2012 (data not yet observed), correcting both for the probability of a failure in the validation stage and the probability of a rejection in the registration stage, to the CERs projected from CDM projects that are already registered, including finally a correction factor for the performance of projects in terms of issuance of credits:

$$CER_{sum\,2020} = ((CER_{subm} + \sum_{2008}^{2012} CER_{\inf l,y})\, p_{valid} * (1 - p_{rej}) + CER_{reg}) * p_{perf} \quad , \qquad (3.1)$$

where:

CER_{subm} = CER volume by 2020 listed in PDDs of projects submitted up to 2008

$CER_{infl,y}$ = CER volume by 2020 listed in PDDs of projects to be submitted in each year between 2008 and 2012

p_{valid} = probability of validation of projects submitted until 2012

p_{rej} = probability of rejection of validated projects by the CDM EB

CER_{reg} = CER volume by 2020 listed in PDDs of currently registered projects

p_{perf} = CER issuance rate in % of CER_{reg}

We do not include possible delays in this formula because, for projects with a 10-year crediting period starting before 2010, any delay will not change overall CER volumes. Delay only matters for renewed projects with 7-year crediting periods.

Equation 3.2 then estimates the amount of CERs that will be generated from projects to be registered between 2013 and 2020, by taking the projected annual inflow of CERs from projects to be submitted for validation and correcting it for delays in the registration cycle, the probability of a failure in the validation stage, the probability of a rejection in the registration stage and the performance in terms of issuance of credits:

$$CER_{add\,2020} = ((\sum_{2013}^{2020} CER_{\inf l,y} * d_{delay,y}) p_{valid} * (1 - p_{rej})) * p_{perf} \quad , \tag{3.2}$$

where:

$CER_{infl,y}$ = CER volume by 2020 listed in PDDs of projects to be submitted in each year between 2013 and 2020

$d_{delay,\,y}$ = percentage of pre-2021 CERs remaining due to delay of project implementation, for each year, calculated according to equation 3.3 below.

The data for CER_{subm}, $CER_{infl,y}$ and CER_{reg}. has been obtained from the UNEP Risoe Pipeline (2009), and result from the projections by the project developers of how many emission reduction credits they expect to obtain until the year 2020. The figures for $CER_{infl,y}$ have been adjusted to account for the shorter crediting period up to 2020 that projects being submitted in the future will have.

Until recently, it was unknown which projects have failed validation as validators did not publish their rejections. In January 2008, the head of the DOE Forum stated in the context of the 38th EB meeting that the five largest DOEs had rejected 369 projects during validation. About two thirds of the rejections were due to a lack of additionality. If one puts the number in relation with all projects registered and submitted for registration by January 2008, the share of rejections would be 32%. Thus, for the probability of validation of projects we assume, for a business-as-usual case, 70%.[19]

Rejection rates have increased over time, from less than 2% in 2005 to 10% in 2007 and early 2008 (UNEP Risoe Centre 2009). We thus take 10% as input for our business-as-usual projection of CDM supply in 2013-2020. Average CER issuance performance is set at 98% of predicted CER generation as achieved in the past. We use this figure for the CER issuance rate in the business-as-usual case. However, issuance performance varies greatly across project types, so that the median performance is only 82%. We use this median for modelling stricter CDM supply scenarios.

Delays in project development lead to loss of CERs before a certain date (2012 or 2020), even if not all of them lead to an overall loss of CERs if the CDM continues afterwards.[20] The effect of this delay on estimated CER volumes depends on a specific project's remaining crediting period and

[19] The UNEP Risoe Centre CDM pipeline started to include information on failure in validation from June 2009 onwards and now uses these figures to also provide a failure-corrected estimation of future CER supply. These figures were, however, not publicly available when the analysis in this chapter was made.

[20] If a project suffers a delay in its registration when its operations have already started, it will lose the CERs for the emission reductions achieved before the date of registration. As project developers can change the start date of a project's crediting period once after registration by simple communication to the CDM Executive Board, a delay of implementation for an already registered project does not lead to an overall loss of CERs during the crediting period, but to a loss compared to the quantity estimated to accrue by a specific date.

would thus theoretically have to be summed up case by case. This also applies to those registered projects whose crediting period only starts in the future. Therefore, the impact of delays depends on the shape of the CER inflow over time. Assuming that the crediting period of all projects coming in during a year would on average begin in the middle of this year, the discount of CERs due to delay can be quantified using the function provided in Equation 3.3:

$$d_{delay,year} = \frac{duration_{pre-2021} - delay}{duration_{pre-2021}} , \qquad (3.3)$$

where:
$d_{delay,year}$ = share of pre-2021 CERs in terms of projected CER level for projects submitted during the current year remaining due to delay of project implementation
$duration_{pre\text{-}2021}$ = number of months between July of year until end of December 2020
delay = delay of project implementation (months)

We assume, for all projects, that the delay in project implementation averages 6 months.

Using the equations and parameters described above, we generate seven CER supply scenarios for the period 2013-2020. In a very strict scenario (Scenario A), only the credits generated from projects registered up to 2012 would be accepted in the global carbon market. In a status quo scenario (B), the CDM would continue with the same rules, stringency, range of host countries and project types as today, continuing to increase credit supply beyond 2012. Following a 'high quality CERs' demand policy by the EU, Annex I countries could agree to no longer accept credits from industrial gas projects (Scenario C). Annex I countries could agree to only accept CERs from LDCs for projects registered after 2012 (Scenario D). Additional measures to create appropriate incentives that promote CDM development in LDCs, added to the rule depicted in Scenario D, would form an active LDC-promotion scenario (Scenario D2). Stronger pressure by developing countries to accept REDD (reduced emissions from deforestation and degradation) and CCS projects and clarify rules for programmatic CDM could lead to a larger CDM supply (Scenario E). Finally, a stricter 'high quality' scenario would allow CERs from post-2012 projects with stricter additionality considerations and again without industrial gas projects (Scenario F).

Table 3.3 provides an overview of these scenarios, their assumptions and calculations. In all cases, we deduct the CER demand projected for 2008-2012, which we have previously estimated will total 3300 $MtCO_2e$ (Michaelowa 2008a), from the overall CER supply for 2008-2020. Based on the current geographical distribution of CDM projects, we estimate supply from the following five regions: LDCs, Latin America, Europe and Middle East, Asia-Pacific other, and Africa other. For scenario D2, to account for the extra inflow of CDM projects from LDCs resulting from active CDM promotion in these countries, we take 50% of the theoretical potential estimated by a World Bank Study for LDCs in Sub-Saharan Africa (De Gouvello et al. 2008) and add it to the CERs projected from the CDM pipeline. The results of our projections are shown in Table 3.4.

Table 3.3: CER supply scenarios 2013-2020: assumptions

Scenario	Description	Values for parameters
A Only CERs up to 2012	Only CERs generated from projects registered up to 2012 are considered for supply up to 2020	p_{valid} = 70% p_{rej} = 10% p_{perf} = 98% supply = $CER_{sum2020}$ – $demand_{2008-12}$
B CDM same	CDM continues with same rules, same stringency and same countries	p_{valid} = 70% p_{rej} = 10% p_{perf} = 98% supply = $CER_{sum2020}$ + $CER_{add2020}$ – $demand_{2008-12}$
C No new industrial gases	CDM continues with same stringency and countries after 2012, but without industrial gas projects	p_{valid} = 70% p_{rej} = 10% p_{perf} = 98% supply = $CER_{sum2020}$ + $CER_{add2020\ (w/o\ ind\ gases)}$ – $demand_{2008-12}$
D After 2012 only LDCs	For projects registered after 2012, only CERs from LDCs are accepted	p_{valid} = 70% p_{rej} = 10% p_{perf} = 98% supply = $CER_{sum2020}$ + $CER_{add2020\ (only\ LDCs)}$ – $demand_{2008-12}$
D2 After 2012 only LDCs with active promotion	For projects registered after 2012, only CERs from LDCs are accepted. Measures to incentivize this supply are in place	p_{valid} = 70% p_{rej} = 10% p_{perf} = 98% supply = $CER_{sum2020}$ + $CER_{add2020\ (only\ LDCs)}$ + $CER_{LDC\ additional}$ – $demand_{2008-12}$
E CDM enlarged	CER generation between 2013 and 2020 with 50% higher potential each year	p_{valid} = 70% p_{rej} = 10% p_{perf} = 98% CER_{infl} is multiplied by 150% supply = $CER_{sum2020}$ + $CER_{add2020}$ – $demand_{2008-12}$
F CDM strict rules	From 2013 stricter additionality, no industrial gases: less validations, more rejections, smaller CER issuance rate	Up to 2012: p_{valid} = 70%, p_{rej} = 10%, p_{perf} = 98% After 2012: p_{valid} = 50%, p_{rej} = 15%, p_{perf} = 82% supply = $CER_{sum2020}$ + $CER_{add2020\ (w/o\ ind\ gases)}$ – $demand_{2008-12}$

Table 3.4: Carbon credit supply scenarios 2013-2020: Projected supply from CDM projects ($MtCO_2e$)

	A	B	C	D	D2	E	F
Scenario / Region	Only CERS up to 2012	CDM same	No new industrial gases	Only LDCs after 2012	Only LDCs after 2012, with incentives	CDM enlarged	CDM strict rules
Africa other	132	171	189	132	132	190	164
Asia-Pacific other	5108	6884	6808	5108	5108	7773	6060
Europe/Middle East	25	35	38	25	25	40	32
Latin America	780	1026	1007	780	780	1150	907
LDCs	55	73	93	73	662	82	76
Total supply 2012-2020 ($MtCO_2e$)	94	128	118	94	94	145	108

3.5 Estimating quantitative impact of scenarios on CER demand from LDCs

3.5.1 Supply-demand balance

The combination of our CER supply and demand scenarios is shown in Table 3.5. In this analysis we have disregarded the potential supply from JI projects. We do this because this instrument suffers from delays in host country approval, because the size of the JI portfolio is very small in comparison to the CDM (with 122 $ktCO_2e$ emission reductions per year expected to be delivered by all active JI projects, it represents about 15% of the CDM pipeline), and because it also constitutes mitigation effort in Annex I countries.

These figures show that the balance between supply and demand of CERs depends largely on whether there is an international agreement (resulting in larger demand) and on whether the CER contribution to abatement in Annex I countries is capped or not (supplementarity). The rules defining CER supply have a much smaller effect than the rules defining demand. For example, when comparing the strictest supply scenario (CERs supplied only from LDCs after 2012) with the most lenient one (CDM enlarged), CER supply increases by about 50%. This is much smaller than the differences found above across the different demand scenarios.

Without an agreement and with a cap to the use of CERs of 50% of the mitigation effort in all Annex I countries, CER oversupply is very likely. With an agreement, it is very likely that the CDM would not provide sufficient credits to cover the potential demand during 2013-2020, even with 50% supplementarity. The scenario with the financial crisis – which also assumes an international agreement is reached – has similar results to the scenario with agreement.

Table 3.5: CER supply-demand balance for 2013-2020 ($MtCO_2e$)

Scenario		1	2	3
		No agreement	International agreement	Financial crisis
A	Only CERs up to 2012	-2699 to 1107	2461 to 8112	2035 to 7347
B	CDM same	-4822 to -1016	337 to 5989	-89 to 5223
C	No new industrial gases	-4758 to -952	402 to 6053	-24 to 5287
D	Only LDCs after 2012	-2717 to 1089	2443 to 8094	2017 to 7328
D2	Only LDCs after 2012, with incentives	-3306 to 500	1854 to 7505	1428 to 6739
E	CDM enlarged	-5884 to -2078	-725 to 4927	-1150 to 4161
F	CDM strict rules	-3852 to -46	1307 to 6959	881 to 6193

Note: The ranges indicate the different supplementarity assumptions, from 50% supplementarity, to freedom to use the CDM for offsetting as much as desired. Negative figures indicate excessive CER supply.

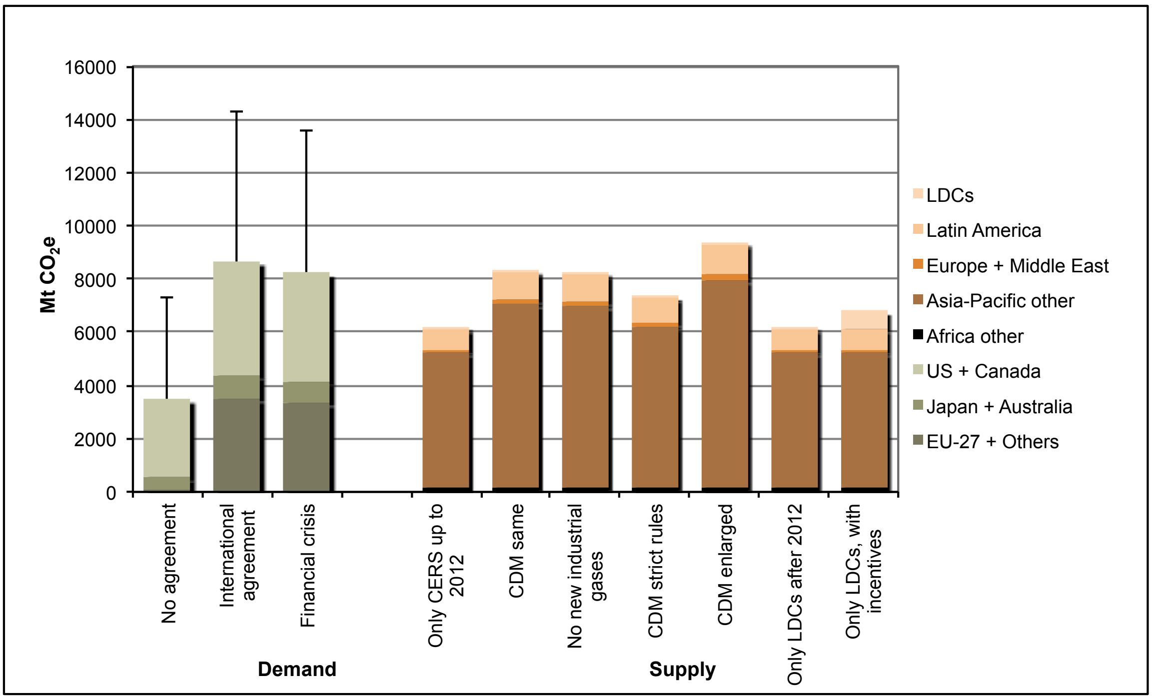
It should be noted that several of these combinations are unlikely. Under a scenario with no agreement, for example, it is unlikely that the CDM will be significantly enlarged, as Annex I countries will not be willing to finance further projects in developing countries. It is also unlikely that having not reached an agreement on climate change mitigation, all Annex I countries would then agree to only accept high quality CERs. However, some parties or groups (such as the EU) could decide to implement these limitations unilaterally. Thus, while not completely realistic, the combination of scenarios shows an overall picture of the range of possible balances in the future carbon credit market from the most optimistic to the most pessimistic possibilities.

Figure 3.5 illustrates how the supply would be spread across regions and shows that under most scenarios, LDCs remain unimportant in the market.

We expected that the scenarios without industrial gases, with strict rules, or with CERs only from LDCs after 2012 would have an impact on supply from LDCs. However, industrial gases are decreasing in the CDM pipeline, falling from close to half in 2004-2005 to just 4% of the new CER supply in 2008. Our projections for 2013-2020 reflect these trends and the fact that the current CDM rules do not allow new installations with industrial gas emissions to host CDM projects. Only if this rule is relaxed, the supply of CERs from industrial gas reduction projects would very likely increase again. The scenario with strict rules is similar. Finally, the scenario with preferential access and incentives that promote CDM development in LDCs after 2012 does show some improvement for these countries, but the supply from all other countries up to 2012 is still much larger.

The scenario analysis has shown that, even under strict preferential access measures that do not allow for CERs from post-2012 projects from countries other than LDCs, the potential CER supply from LDCs is very small compared to the available supply from other countries. We should also remember that this supply from LDCs will only materialize if the existing barriers for CDM project implementation in these countries are overcome, as seen when comparing scenarios D and D2. This finding is in line with the conclusion reached by Bakker et al. (2011) that preferential treatment for under-represented countries in the CDM will have a limited contribution to improving the geographic distribution of CDM projects.

Figure 3.5: Supply-demand balance 2013-2020



Note: For the demand, the main columns indicate the situation when countries are only allowed to cover up to 50% of their emission reductions through CDM credits; the 'error bars' show demand when there is freedom to use the CDM for offsetting as much as desired.

The promotion of PoAs, which can address the smaller and more dispersed emission sources that are more likely to exist in poorer countries, could provide an opportunity for incentivizing the CDM in LDCs. Special incentives could be provided through the provision of technical support for coordination entities that set up such programmes, and through the financing of their upfront costs (PDD development, methodology development, registration and validation, and coordination of first participating project activities).

Generally, PoAs have a high "leverage", i.e. if they are successful, they can expand quickly without any further delays in the CDM project cycle. For example, an Indian PoA aims at distributing 400 million compact fluorescent lamps (CFLs). However, drawing on our knowledge of CFL projects, we estimate the total volume of lamps distributed by the end of 2012 by the three PoAs in the pipeline at 90 million. For stove PoAs, the total volume could reach 3.5 million stoves by that time. 1.7 million domestic biogas plants and 1350 swine farm digesters could become operational before 2013, which would be in the same order of magnitude as the most successful development assistance projects covering these technologies.

PoAs not only have to show that they actually generate the large reductions they foresee, they also need to demonstrate that they will allow LDCs to harness an eventual preferential access to the CDM market. A positive indicator of increased attention to LDCs is that some private sector companies like JP Morgan and C Quest Capital are entering the PoA market in countries that would never be appealing for such companies in a "normal" business context. Thus, eventually, the development target of the CDM and the aim to generate cheap CERs could be reconciled.

Still, what are the potential risks that a preferential access measure may entail? What can experience tell us about how these policies work in practice? In the following section, a preferential access agreement in the international trade sector is analysed in order to draw lessons for the climate regime.

3.6 Discussion of preferential access options

In the world trade system, there is a case that could be used to illustrate the effect of preferential access options for a specific group of countries. The Lomé Convention, first signed in 1975 and renewed three times afterwards, is a trade and aid agreement between the European Community (EC) and 71 so-called ACP (African, Caribbean and Pacific) countries. It establishes the basis for trade and development cooperation between these two groups of countries, motivated both by Europe's interest in guaranteeing the supply of raw materials, and by their wish to support ACP countries' sustained development. The Lomé agreements set preferential access quotas for agreed agricultural products that were allowed henceforth to enter the EC market free of duty. While these agreements are no longer in place due to their incompatibility with World Trade Organization (WTO) rules, they are still an interesting case study for illustrating the limitations of preferential access policies.

According to Cosgrove (1994), ACP exports to Europe accounted for 3.4% of total EC imports in 1975, when the first Lomé Convention was signed. Due to the large growth in EC trade, ACP exports declined to 1.5% of EC imports in 1992. While ACP exports to the EC did grow in absolute terms, they could not keep pace with the growth in the European market. Cosgrove concludes that the Lomé Convention did not provide sufficient support to enable ACP countries to keep their market share, and that it therefore failed in its goals.

The preferences generated by Lomé for ACP exports were highly dependent on the barriers that the EC placed for trade in general. For agricultural products, the general rule is that the more processed the product is, the more barriers it faces. Thus, ACP countries would have benefited most from adding value to their raw materials and exporting them to Europe in processed form. Trade also depends on the current prices of commodities. During the 1980s and 90s, the prices of agricultural products mainly fell, which also had a negative impact on ACP trade. Finally, the increase in trade from the preferred country group also depends on the elasticity of demand for the product. The elasticity of demand for most ACP products in Europe is low, meaning that a lower price for them (offered by ACP countries as a result of the trade preferences) had little effect on their export volume (Cosgrove 1994).

Some non-traditional products have been identified as benefiting from the Lomé Convention, among them canned tuna, leather and leather products, fresh flowers, some vegetables, textiles and garments. Many of these products were subject to levies from the European common agricultural policy (CAP), and thus profited from a comparative advantage under Lomé. In Mauritius, the strong specialization in sugar exports to the EC enabled the accumulation of funds that were used to shift the economy towards the textile industry, tourism and financial services (Laaksonen et al. 2007). Despite these successes, the main barriers inhibiting ACP export performance could not be overcome by a trade agreement: climatic conditions (droughts and desertification), crop and livestock diseases, lack of infrastructure leading to high transportation and communication costs, oil price increases, and AIDS continued to restrict the development and integration of ACP countries in the world market (Cosgrove 1994).

The Lomé experience provides lessons for the climate regime. Through Lomé, not just access to a market was secured, but that access came with fewer costs (no tariffs or levies). In the climate regime, CDM projects from LDC countries benefit from a zero registration fee. However, registration is only a small fraction of CDM transaction costs, whose bulk encompasses PDD development, methodology development (if needed) and validation. Providing upfront financing for PDD development and validation in countries with little CDM development has been agreed on, but funds are limited and this provision not only targets LDCs, but all countries with less than ten registered CDM projects. If similar financing, for example, for the coordination of PoAs with high sustainable development benefits could be provided, not only could the CDM potential of LDCs be realized, but also a better contribution to local development could be made. It would be important, however, to keep these incentives targeted specifically at LDCs.

In the EU climate package, some degree of preferential access for CDM projects from LDCs has been secured, but no provisions are yet in place for further supporting the implementation of these projects. As seen in the Lomé experience, the underlying causes of poor countries' lack of competitiveness need to be addressed.

Furthermore, in Lomé, success was observed for special types of products with added value. A parallel could be made here to CDM project types with added value (sustainable development benefits or stricter additionality, for example), but only if this added value is transformed into some kind of financial incentive that supports these projects. This kind of differentiation between project types is not yet in place in the climate regime. PoAs could constitute an opportunity in this context. These programmes seem to have a stronger focus on small-scale projects with higher sustainable development benefits than individual CDM projects, and so far represent a higher share in LDCs. Special quotas or special treatment for PoAs could be an opportunity to introduce such a differentiation, without explicitly differentiating between project types or host countries. As PoAs nonetheless run the risk of failing to deliver for LDCs if the costs of coordinating individual activities are too high, support for PoA coordination in LDCs could be offered in addition.

A further issue is the source of financing for such preferences. In the Lomé conventions, the EU was a relatively homogeneous group of countries that could agree on securing financing for the trade and aid components of the agreements. In the climate regime, the loan scheme for CDM project development in underrepresented host countries described above only covers the costs of the paperwork required to comply with the project cycle. Finance for the project implementation itself still needs to come from external equity or debt investors. The Copenhagen Accord provides an opportunity, as it led to a generic pledge by industrialized countries to finance mitigation and adaptation in developing countries. However, the modalities for this finance are still unclear (see Roberts et al. 2010 for a discussion on open questions about the finance promise, and World Resources Institute (WRI 2010) for a summary of the financial pledges with comments on whether they are new and additional). In addition, this finance pledge does not include specific provisions for LDCs.

The discussion of compatibility of preferential access measures with the rules established in the international trade regime is a final lesson that can be learned from the Lomé experience. The trade preferences for ACP countries were abolished due to their incompatibility with the WTO regime. In the carbon trading area, conformity with WTO rules is still an under-developed and under-researched topic. Howse and Eliason (2009) provide a short exposition of possible ways to rule carbon trading, including the CDM, under WTO. According to them, the WTO has so far not decided whether (and how) it will tackle carbon markets. Thus, trading of Kyoto Protocol units is currently governed by the Kyoto Protocol and the UNFCCC, and trading of other carbon permits (such as EU ETS allowances) is so far not addressed by any international agreement.

If WTO were to rule carbon trading, it first needs to be defined what type of assets are emission permits or credits. Depending on whether they are treated as financial services, other services or goods, different trade rules would apply. If emission credits are considered as goods or services, then the WTO's 'most-favoured nation' and 'national treatment' provisions would become applicable to the CDM. In this case, unilateral discrimination by buying countries (for example, the EU deciding not to buy CERs from countries that do not apply certain sustainability criteria) would not be WTO-conform. Under this lens, even the current discrimination against forestry CERs in the EU ETS could be considered to violate WTO rules (Wiser 2002). Similarly, the preferential treatment options discussed in this chapter would mostly not be WTO-conform. However, Wiser agrees with other authors (e.g. Kim 2001) in the opinion that CERs cannot reasonably be regarded as goods (they are not tangible things) and that, if clearly defined as a licence or permit issued by an authority (the CDM Executive Board), they cannot be considered services either. In this case, it is the COP/MOP who has the sole authority to decide how CERs are traded between parties. Regarding CERs as licences would also allow parties to enact domestic regulations that restrict their use in ways not specified under the international rules, as in the case of the EU climate package.

In summary, while it is not clear whether the CERs deriving from CDM projects can be considered as "goods" or "services" that are regulated under the WTO, analysts suggests that, in this case, preferential treatment towards CERs from specific origin could be deemed non-WTO conform.

Thus, authors discussing the interface between the Kyoto Protocol and the WTO suggest that caution should be taken to avoid potential disputes between both regimes – for instance through clear definition of the nature of emission reduction credits.

3.7 Conclusions

The current and potential supply of CDM projects from Least Developed Countries is low as many barriers prevent their participation in the carbon market. However, the case of Honduras shows that with limited international financial sources, local entrepreneurship and leadership can bring successes in the CDM when coupled with external aid to set up appropriate institutions. LDCs have a substantially higher share in CDM Programmes of Activities (PoAs) than in individual CDM projects.

Both in the international climate negotiations and by the EU, options have been proposed for fostering CDM development in LDCs. While the financial incentives agreed internationally are available for all countries hosting less than 10 CDM projects, preferential access to part of the European carbon market is granted to CERs from LDCs through the new EU climate and energy package.

By projecting possible CER supply and demand scenarios for the period 2013-2020, we find that the supply-demand balance largely depends on the level of ambition of Annex I countries' targets and on the degree of supplementarity on the use of CERs for meeting them. A restriction on the supply of CERs from CDM projects registered after 2012 to only LDCs would not have an important impact on CDM project distribution across host countries if the existing barriers for project implementation in LDCs are not overcome and the current trends in project submission from these countries are maintained. Other likely limitations in CER supply on the basis of project quality would have an even smaller effect. Given the little abatement potential available in LDCs this is not surprising, and raises questions on the appropriateness of offsets for fostering mitigation in less developed countries. Perhaps other approaches, such as Nationally Appropriate Mitigation Actions, which would be financed through international cooperation, are more promising.

Drawing a comparison between preferential access agreements in the agricultural trade system (Lomé Conventions) and the climate regime, we find further evidence that not just preferential access is important, but also reduced access costs. The current registration fee exemption for LDCs represents only a small fraction of CDM transaction costs and is probably not enough. The now agreed loan for PDD development and validation of CDM projects will be applicable to all countries with less than ten CDM projects, diluting the benefit for LDCs. An opportunity could arise if similar financing could be provided for PoAs, which have a substantially higher share in LDCs. Furthermore, the limited impact of the Lomé agreements on ACP trade was partly due to the fact that the underlying causes of lack of competitiveness were not addressed. In the climate regime, if CDM implementation barriers are not directly addressed, the CDM might remain a dream for poor countries. Increased incentives for products with added value led to the few success stories in the

Lomé framework. For the climate regime, this could be translated into added financial incentives for CDM projects with added value – however this may be interpreted. Again, PoAs could constitute an opportunity here, as they so far seem to focus on project types with higher sustainable development benefits. Finally, financing was identified as a critical issue for undertaking these measures: if financial incentives for special projects or specific regions are to be created, clear rules for their provision and distribution will need to be reached and enforced.

4. THE IMPACT OF DISCOUNTING EMISSION CREDITS ON THE COMPETITIVENESS OF DIFFERENT CDM HOST COUNTRIES[21]

4.1 Introduction

Through the CDM, greenhouse gas emission reductions from projects in developing countries can be acquired by industrialized countries to comply with their Kyoto Protocol emission reduction targets. Each tonne of CO_2-equivalent emission reductions achieved by the CDM generates one emission credit, which is then used by industrialized countries (or companies in them) to offset their own emissions. Thus, each tonne reduced by a CDM project allows increasing emissions in industrialized countries by one tonne. Theoretically, this is not a problem as long as the reduction from the CDM project is real and as long as incentives for introduction of emission reduction policies in developing countries are not distorted.

The key criterion for ensuring that emission reductions from CDM projects are real is "additionality". Additionality means that a CDM project has to be outside the "business-as-usual" development scenario for its region or country. This is, there are financial, economic, technical or other barriers for its implementation, which only the CDM incentive manages to overcome. This is a necessary condition for CDM projects to really contribute to reducing global GHG emissions: If a CDM project is not additional, using its emission credits to offset emissions in industrialized countries will lead to an actual increase in emissions. There is substantial criticism that a significant amount of CDM projects does not have a very credible additionality argumentation (see e.g. Michaelowa and Purohit 2007; Schneider 2007; Castro and Michaelowa 2008).

The CDM was designed with the aim of introducing developing countries to climate mitigation in a voluntary manner, without affecting their development objectives. It could be regarded as a transitional step before these countries also commit to own emission reduction targets. Nonetheless, as described in the previous chapters, poorer countries face substantial barriers for accessing the mechanism, and hence the CDM project portfolio is very unevenly distributed across potential host countries.

---

[21] This chapter is based on an article previously published as: Castro, P. and Michaelowa, A. (2010), 'The impact of discounting emission credits on the competitiveness of different CDM host countries', *Ecological Economics*, vol. 70, no. 1, pp. 34-42.

While economic efficiency considerations dictate that the emission reductions should first take place wherever they are cheaper, equity concerns suggest that the CDM incentive should be more proactively directed towards less developed countries. These concerns are politically founded on the second goal of the CDM, which is to contribute to sustainable development in its host countries. In addition, more autonomous climate mitigation action by advanced developing countries (beyond just offsetting) is needed to achieve the long-term environmental goals of the climate convention, which would mean that a system for gradually phasing out the CDM in these countries is needed (Cosbey 2005; Schneider 2009).

Discounting the value of emission credits with a differentiation between host countries has been proposed as another possible approach for addressing not only the geographical distribution of CDM projects, but also concerns about long-term incentives for host countries and about unclear additionality. As we will elaborate further below, discounting could be used to compensate for fictitious reductions from non-additional CDM projects; it could be designed to increase the incentive for advanced developing countries to move from the CDM to own mitigation commitments; and it could also be applied to improve the competitiveness of less developed countries as hosts for CDM projects.

Discussion on the benefits of discounting for shifting incentives in the CDM has been very limited in research so far. Bakker et al. (2011) use aggregate data for the whole non-Annex I region to compare the potential impacts of several systems of differentiating CDM host countries or project types (including discounting) on the carbon market; however, their analysis provides very little insight on their effects on the geographic distribution of the CDM. This chapter seeks to address this gap by assessing the impact that discounting could have on the distribution of CDM projects across several host countries or regions, with a special focus on Least Developed Countries and Sub-Saharan Africa. Methodologically, a large component of the work in this (and the following) chapter pertains to the estimation of CDM projects' abatement costs and the construction and comparison of CDM-specific Marginal Abatement Cost (MAC) curves for four major countries or regions within non-Annex I with and without discounting of emission credits. Thus, the methodological contribution of this chapter is the definition of a method for estimating these abatement costs in a credible and comparable manner, the elaboration of a dataset that provides this information for all project types with sufficient financial information available, the consolidation of this information by means of MAC curves, and the analysis of how discounting would affect such MAC curves.

Section 4.2 briefly summarizes the existing research on discounting emission credits and its possible impacts on carbon markets. In section 4.3 we discuss the relationship between discounting of emission credits and host country competitiveness in the CDM. In section 4.4 we define our methodology for estimating CDM-specific abatement costs and potentials, and present results for different project types in Africa and other CDM host regions. Section 4.5 analyses the impact of two emission credit discounting schemes on the competitive position of these CDM host regions by looking at the remaining CDM potential in these country groups on the basis of MAC curves. Section 4.6 discusses the results and draws the conclusions from this chapter.

4.2 Discounting emission reduction credits

Discounting CDM emission reductions means that not all reductions generated by a project enter the carbon market, so that part of the effort is not used to offset emissions elsewhere. For example, if a CDM project generates 100 tonnes of CO_2 emission reductions, applying a 20% discount factor would imply that only CERs for 80 tCO_2 of reductions would be generated. As a result, from the 100 tonnes of emission reductions achieved only 80 enter the carbon market, and the remaining 20 tonnes of reductions can be considered to be real global GHG emission reductions beyond offsetting (Schneider 2009).

Why could such a discounting policy be desirable, if the CDM is intended to make emission reductions cheaper? Discounting was first proposed by Greenpeace (2000) as a measure to safeguard the environmental integrity and the additionality of the CDM. This was a response to the widespread critique that it is very difficult to prove that a project proposed as CDM is not a business-as-usual situation and is thus leading to "real" emission reductions. Using discounting to safeguard additionality is however a complex task, as it would imply knowing the share of non-additional credits being issued despite all quality checks, and modifying the discount factor over time to reflect possible changes in this share. This would deter investors and, more importantly, penalize both non-additional and truly additional projects. For a numerical example of how additionality-based discounting could work, see Michaelowa (2008b).

The early discussion on discounting also suggested that it could be used to compensate for the uncertainty related to establishing baselines, to provide an incentive for greater domestic action in countries with reduction targets, and to penalize negative social and environmental effects of CDM projects (Jackson and Begg 1999). Ten years later, the discussion still focuses on using discounting for improving the CDM's environmental integrity, while influencing other shortcomings of the mechanism as well. Environmental Defense (2007), for example, proposed to differentiate discount rates across countries in order to 'discourage further use of the CDM by large emitting developing countries and to direct the mechanism towards poorer developing countries' (p. 2). This is in line with the political objective, enshrined in the Kyoto Protocol itself, that the CDM should assist developing countries in achieving sustainable development, and that it should do it in an equitable manner (UNFCCC 2001b). It is also in line with the now recognized fact that the current system of emission reduction targets for industrialized countries and the CDM for developing countries is not enough for ensuring a long-term stabilization of the climate system (Gupta et al. 2007a). More climate mitigation action by developing countries, especially the large and advanced ones, is needed.

Chung (2007) proposed discounting as contribution of developing countries to global emission reductions without having to resort to country-specific commitments. This idea could be developed into a system where discounting provides an incentive for advanced developing countries to take up emissions reduction commitments beyond the CDM. Discounting would build such an incentive, as taking up a commitment means that reductions achieved through domestic reduction projects count 100% (nationally and in the international carbon market), whereas under the discounting scheme, they would be valued less. The incentive would increase if the discount factor were progressively linked to the level of development of the host country (Michaelowa 2008b). Discounting by countries could also be used to promote CDM project development in African and Least Developed Countries by applying lower or no discount rates (or even granting more credits than reductions actually achieved) for projects in these countries (Schneider 2009).

Discounting could also be varied according to project types, as suggested by Chung (2007) and elaborated by Schneider (2009). Thus, projects with beneficial characteristics could be favoured over less desired ones by assigning them a lower discount rate, no discount rate or even a multiplier above one. For example, projects with large sustainable development benefits or using innovative technologies could be favoured, while projects with very large windfall profits or questionable additionality could be burdened. Despite these promising features, agreeing upon such a set of different discount rates could become very challenging at the UN level. Sustainable development priorities are defined differently by each country and their valuation is still very subjective and complex. The level of innovativeness of a technology is subjective to contextual factors, e.g. to the host country. Additionality depends not only on project type, but also on country-specific factors. This complexity would make it difficult even for technical experts to set appropriate discounting factors. Therefore we do not assess this type of discounting.

There are basically two approaches for implementing a discounting policy in the CDM. Supply-side discounting implies that only a certain fraction of the verified emission reductions leads to issuance of emission credits. This type of discounting would require an agreement at the UN level, but would have the advantage of being applicable to the whole carbon market. Demand-side discounting means that a percentage of the issued credits is retired from the market by the buyers, sending it for example to a cancellation account. Demand-side discounting allows for different credit buyers to set different discount rates, which would complicate the linking of different emission trading schemes and could distort emission credit prices (Schneider 2009).

While demand-side discounting makes little sense from a business point of view, as demanding countries are expected to aim at getting as many credits as possible for the lowest price, political and environmental reasons are influencing these decisions. The EU's qualitative restrictions for CERs from 2013 onwards discussed in the previous chapter are an example of a politically motivated move away from the rationale of "the more, the cheaper, the better". Similarly, the American Clean Energy and Security Act that was passed in the US House of Representatives in June 2009 included a discounting provision for international offsets (which would include CDM credits): from 2018 on, one international offset would be equivalent to 0.8 emission allowances in the US market (Pew Center 2009). The reasons for such a demand-driven discounting scheme are threefold: improving the environmental integrity of the scheme, promoting domestic green jobs by favouring domestic reductions (or domestic offsets) over international ones, and addressing fears about the competitiveness effects of financing foreign industry through the purchase of international offsets. As the American market, if such a law is ever approved, would become the largest carbon market in the world, carbon credit sellers would not be able to escape such a unilateral discounting provision.

Whether discounting is implemented through an agreement at the UN level, or established unilaterally by large CER buyer countries, the effect will be similar: CDM projects will be awarded less emission reductions than they achieve. As we are interested in the proposals that seek to use discounting to shift incentives for mitigation in developing countries, in the following analysis we use Environmental Defense's and Chung's suggestions that discounting could be used to improve the geographical distribution of CDM projects as a starting point, and elaborate on Michaelowa's proposal for a differentiation between host countries. On this basis, we try to answer the question whether such a discounting scheme with differentiation between host countries could really have an impact on host country competitiveness in the CDM market, with focus on LDCs.

4.3 Discounting emission credits and host country competitiveness

Discounting emission credits will have an impact on the value and on the amount of emission reductions from different CDM host countries. The higher the discount rate, the less credits are issued or traded for the project, and thus the higher becomes the abatement cost per credit. At the same time, the higher the discount rate, the less emissions reductions are credited, so the more the mitigation potential is penalized. Increased costs and reduced potentials are likely to lower the competitiveness of the CDM host countries affected by discounting.

As detailed in Chapter 3, the competitiveness or attractiveness of individual CDM host countries depends on several general and CDM-specific factors, among them, the availability of emission reduction options; the host country's business environment; the institutional framework relevant for investments in general and the CDM in particular; the availability of capital and finance; the existence of historical business or aid relationships with potential credit buyers; and the capacity to handle the technologies and/or the baseline methodologies needed for the CDM.

Discounting emission credits will clearly have no effect on the host country's business environment, on the institutional framework or on technological and methodological capacity. Some other measures have been undertaken in several countries to overcome at least the institutional barriers, so that these aspects will not be included in the analysis in this chapter. Discounting could contribute to further improve project-specific and cost-related factors by shifting the financial incentives of the CDM towards more backward countries, and could thus contribute to fostering CDM development in, for example, Sub-Saharan Africa or the Least Developed Countries. However, more structural factors, such as political and economic stability, mitigation potential, technical capacity, and infrastructure are more difficult to change in the short term.

As discounting will not have an impact on the institutional criteria but rather on the value of emission reductions from different countries, we will focus our subsequent analysis on the host country potential for specific abatement technologies, and their abatement cost, which will be used to construct CDM-specific marginal abatement cost curves.

4.4 Estimating emission credit costs and CDM potentials

4.4.1 Marginal abatement cost curves

As explained above, discounting will affect both the amount and the value of emission reductions from the CDM. We can model these on the basis of abatement costs and potentials and the resulting marginal abatement cost curve. Abatement costs describe the costs society has to bear to reduce one tonne of CO_2 emissions – or the equivalent amount of other greenhouse gases – using a certain mitigation activity. They determine the cost-effectiveness of individual policy or project choices. Abatement potentials – the volume of emissions reductions that can be achieved by applying a specific technology in a specific region or country in a certain period of time – describe the amount of mitigation that is feasible. Costs and potentials for different technologies in a country or region are usually displayed graphically together to form a marginal abatement cost curve (MAC).

MAC curves are used extensively in environmental economics to link a firm's (or a country's) pollutant emission levels and the cost of each additional unit of pollution reduction (McKitrick 1999). Examples of the use of MACs at the firm and at the country level can be found in Ellerman and Decaux (1998), Criqui et al. (1999) and McKitrick (1999). MAC curves for climate mitigation can be derived using a top-down approach by means of macroeconomic models with a detailed energy sector component. They can also be obtained on the basis of engineering data of emission reduction technologies using a bottom-up approach (Criqui et al. 1999).

Climate-economy models use these curves systematically (see e.g. Kuik et al. 2009 for a meta-analysis). However, abatement cost estimates are frequently based on expert opinion, or on model assumptions regarding, among others, the climate policy target, the emissions baseline, discounting rates, and future technological options. Further, there are only a few abatement cost and potential studies that focus on developing countries. Two good examples are the efforts by Wetzelaer et al. (2007) and Bakker et al. (2007) to build an abatement cost curve for these countries in the years 2010 and 2020, respectively. Recently, the consultancy McKinsey has started to develop global and country-specific MAC curves for the year 2030, which have eagerly been taken up in the international climate policy debate (see Enkvist et al. 2007 for an overview). However, as the assumptions and methodology used in the McKinsey curves are not publicly accessible, in this study only bottom-up MAC curves and abatement cost and potential estimations, with more transparent assumptions that are easier to control for and discuss, were used.

Still, a drawback of the reliance on abatement cost curves is that they usually only include the direct investment and operation costs of the abatement options, overlooking potential information and transaction costs that can make them much more difficult to implement in practice.

Right now, some individual CDM host countries or regions have sufficiently large CDM project portfolios to be able to empirically estimate the cost of emission credits for specific project types, and possibly, regions. In addition, assessments of GHG mitigation potentials in different regions, including Africa, are available from the literature (Bakker et al. 2007; Vattenfall 2007; Wetzelaer et al. 2007; De Gouvello et al. 2008).

On the basis of empirical MAC curves for specific regions, we can estimate how different discounting schemes could affect those regions' competitiveness in the emission credit market, if we assume that abatement costs and potentials are the main criteria for locating CDM projects (and that the institutional issues described in section 4.3 are (at least partially) captured in the project cost estimations, e.g. through larger financial discount rates in less business-friendly countries, or through larger costs of debt in countries with small financial markets).

4.4.2 Sample selection

We are interested in the effect of a scheme that introduces discounting of CDM emission credits with a differentiation across host countries according to their level of development, as the literature argues that such a differentiation will contribute to improving the geographical distribution of the CDM portfolio.

As will be described in detail in section 4.5, such a discounting and differentiation scheme will apply the strongest discount factors on countries that the highest per capita emissions and GDP levels, and the lowest on countries with low emissions and income levels. For getting an empirical idea of the potential impacts of such a discounting scheme, thus, we compare how discounting would affect the emission reductions of four non-Annex I countries or country groups that are representative of the range of effects of discounting:

- High income, high emissions countries (Israel, Qatar, Singapore, South Korea, United Arab Emirates): in this group of countries, discounting factors will be highest
- China: as the major CDM host country, which, due to its rapid economic and emissions growth and its size is expected to act more proactively to mitigate climate change soon, it is interesting to see how discounting may affect its portfolio
- India: the second largest CDM host country, which however, has still low per capita income and emission levels, so that discounting may not affect it significantly
- LDCs: with generally very low income and emissions per capita, they will not be affected directly by discounting, but are expected to benefit indirectly because discounting will make the other countries lose competitiveness in the CDM.

For building the CDM MAC curves that will be used to compare the effects of discounting between these four regions, we need to gather cost data from CDM projects that are representative of them. We focus for this purpose on the project types[22] that are more relevant for these groups of countries, and concentrate on collecting cost data that covers as many of these project types as possible. For project types that still have very few projects with cost information (and even no projects with cost

[22] In the CDM, projects are classified in 'project types', which provide a broad indication of both the generic technology used to reduce emissions (e.g. wind energy, hydro energy with a dam, biogas production, energy efficiency improvements) and of the sector in which it is applied (e.g. energy, waste management, industry, forestry).

information within the country groups described above), data was gathered also from countries outside these groups.

4.4.3 Emission credit costs

General CDM project information is available from a public database, the CDM pipeline, which is maintained and updated monthly by UNEP Risoe Centre (UNEP Risoe Centre 2009). More specific information for each project is also publicly available in the Project Design Documents (PDDs) that can be downloaded from the CDM website of the UN. This documentation often includes a financial analysis, as this is one possible method for demonstrating that a project complies with the CDM requirement of additionality: if the analysis shows that the project needs the subsidy from the CDM to be financially attractive, then it is deemed additional.[23]

Project financial information can be provided in the PDDs as Internal Rate of Return (IRR), as Net Present Value (NPV), as full cash flows or not at all. As shown in Equation 4.1, we define a project's abatement costs as the net present value of the project costs (investment and operation) minus its revenues (e.g. income from electricity sales), all divided by the amount of GHG emission reductions it expects to achieve (which is indicated by the amount of emission credits the project expects to generate over its crediting lifetime, also time-discounted).[24]

$$C(CDM)_i = \frac{\sum_{t=1}^{n} \frac{(C_t - R_t)}{(1+r)^t} + I_0}{\sum_{t=1}^{m} \frac{A_t}{(1+r)^t}} \tag{4.1}$$

Where $C(CDM)_i$ is the abatement cost of project *i* in USD/tCO_2e, *t* the time period, *n* the operative lifetime of the project and *m* its crediting period (all in years); C_t and R_t the operation costs and the non-carbon revenues in year *t*, and I_0 the initial investment; A_t is the abatement achieved by the project in year *t* (in tCO_2e); and *r* is the discount rate. All costs are expressed in US dollars, calculated either using the current interbank exchange rate at the time the project was proposed, or using the exchange rate provided by the project developer in the documentation. This cost calculation approach is similar to the one used by Rahman et al. (2009) in a recent empirical study on the cost structure of CDM emissions abatement, but our calculations differ on the treatment of the annual abatement, which are discounted in order to be able to interpret abatement costs in constant terms (however, our main results are not affected if undiscounted emission reductions are used in the denominator).

---

[23] The demonstration of additionality is a crucial step for CDM project approval. It is usually performed by applying a standardized tool, whose central pieces are either a 'barrier analysis' or an 'investment analysis'. The first one is intended to describe the barriers of technological, financial or other nature that would prevent the implementation of the project in the absence of the CDM, while the latter should show that the financials of the project (e.g. internal rate or return or net present value) are not attractive without the CDM. It is up to the project developer to choose which one of these analyses he wishes to apply.

[24] In this definition, the savings in energy consumption or the cost of alternative investments are also considered as revenues, so that the incremental costs of emission reductions constitute our abatement costs.

Overall abatement costs provide a measure of the profitability and attractiveness of the project. If the costs are negative, the project is profitable even without the CDM revenue; if they are low enough, they can be compensated through the sale of credits; and if they are too high, the project is not profitable even with emission credit sales. However, not only this overall profitability is relevant for the decision to undertake a project, but also the upfront costs, since they need to be covered by financial resources that are frequently scarce, risky and difficult to access in developing countries. Therefore, in this chapter we also analyse project investment costs per credit.

Abatement and investment cost estimations were carried out for a sample of CDM projects in 16 host countries that, as explained above, covers the most important project types in the groups of countries that are focus of analysis.

The data collection effort was started in projects in China, due to its large project portfolio, which makes it easy to compare similar projects and their abatement costs and thus find possible outliers; its tendency to use the investment analysis for additionality demonstration rather than the barrier analysis, which rarely provides sufficient financial information; and the large diversity of project types and sizes being implemented there. Next, cost data was collected from LDCs and other poor countries (e.g. those in Sub Saharan Africa), with the aim of having projects that respond to the characteristics of these countries. However, as of end of 2008 there are only 26 registered projects in LDCs and other countries in Sub-Saharan Africa (SSA), few of which contain sufficient financial information. Hence, we also collected data from other countries hosting types of projects that are also frequent in LDCs. Finally, cost data was also collected from any other project types that were had been developed in the other groups of countries in our sample (here again, when necessary looking at projects in other host countries), so that coverage in terms of project types was as complete as possible. The sample consists thus of 108 projects from 17 project subtypes in 16 countries, as can be seen in Table 4.1.

Full abatement costs

We assume that abatement costs depend mainly on the technology (i.e. the CDM project type) involved, and that the host country has relatively little effect on abatement costs (this assumption relies on the fact that clean technologies are usually state of the art technologies that are traded internationally, and thus have relatively homogeneous costs worldwide). This allows us to pool the project cost data by project type. Ideally, to account for possible differences in abatement costs across countries, we would have built separate databases for each country. This is not possible because the cost data information for several project types is not yet sufficient. However, we try to control for two factors that may affect abatement costs independently of the technology in use.

Table 4.1: Project sample

Project subtype	Sample size	Project financial discount rate(s) (%)	Median project lifetime (years)	Host countries for data collection
Biogas power	7	7, 8, 10, 15, 16	10	China, S. Africa, Guatemala, Honduras, India
Biogas flaring	4	10	8.5	Brazil, Armenia
Biomass energy	8	7, 8, 10, 15	20	South Africa, Kenya, China
Cement blending (*)	2	-	25	India, Indonesia
Coal mine methane	5	8, 11.8, 13.5	15	China
Energy efficiency generation	8	8.5, 10, 12, 13, 15	19	China
Fugitive gases	4	10, 15, 20	15	Qatar, India, Indonesia, Nigeria
Hydro existing dam	6	4, 8, 12, 14, 15	25	China, Brazil, South Korea, Peru
Hydro new dam	6	8, 10, 12	26	China
Hydro run of river	5	8, 10	27	China
Landfill gas composting	7	8, 8.5, 10, 12, 15	10	China, Bangladesh, Indonesia, Malaysia
Landfill gas flaring	4	8, 10, 13.75	10	China, South Africa, Indonesia, Malaysia
Landfill gas power	9	8, 8.5, 10, 12	15	Bangladesh, China
N_2O (adipic)	4	0 - 15	26	China, Brazil, South Korea
N_2O (nitric)	10	0 - 15	21	Brazil, South Africa, Colombia, China
New gas power plant	6	8	20	China
Wind	13	8	21	China

These two important factors in the abatement cost calculations of a project – also shown in Table 4.1 – are its expected lifetime and the financial discount rate used for obtaining its present value. Cost calculations in CDM projects have the tendency to consider a lifetime equal to its crediting period, even if the project will have a longer life.[25] As most CDM projects choose a 3x7-year crediting period, the lifetime considered in the calculations tends to be 20 or 21 years. Some projects even consider just 7 years, especially those where the only income stream is the emission credit revenue. Some others – especially hydro projects – acknowledge a longer operational lifetime, but consider the CDM revenue only during the crediting period. We do not homogenize project lifetimes, but take the lifetime that most likely informed the investment decision by the project proponent: the CDM crediting period, in the case of projects with only income from emission credits, or the whole operational lifetime, in the case of projects with other revenue streams.

Project financial discount rates and financial benchmarks are also chosen by the project proponent, but need to be justified. Financial discount rates appear to be relatively constant within countries and sectors, at least within the energy sector in China, where most projects use a factor of 8%, and smaller or riskier ones apply 10 or 12%. Still, there is significant variation in the financial discount rates chosen for projects in the energy efficiency category, for example, maybe due to the high variety of industries implementing

[25] The crediting period is the period of time during which a CDM project is entitled to receive emission credits. Project developers can choose between a fixed 10-year crediting period or a 7-year crediting period that can be renewed up to two times (thus totalling 21 years).

these efficiency measures (cement, chemicals, iron and steel, coke ovens, etc.). In order to have comparable information and to avoid the possible effect of financial discount rates being manipulated by project developers to obtain more convincing financial figures, we homogenize the financial discount rates in each host country.[26] The choice of financial discount rate is guided by the rates proposed by most CDM projects in the respective country. In countries where the project documentation does not supply this information, a default 10% has been taken. See Table 4.2 for an overview of host countries, financial discount rates used in them, and standardized financial discount rates.

Table 4.2: Host countries and financial discount rates

Host country	Number of projects in sample (*)	Range of financial discount rates used in project documents	Standardized financial discount rate for abatement cost calculations	Source
Armenia	1	10%	10%	Project documents
Bangladesh	2	12%	12%	Project documents
Brazil	7	0 - 25%	10%	Project documents
China	68	7 - 13.5%	8%	Project documents
Colombia	1	not available	10%	By default 10%
Guatemala	1	7%	8%	Project documents
Honduras	2	not available	10%	By default 10%
India (*)	4	14.72 - 16%	15%	Project documents
Indonesia	4	10 - 18%	10%	By default 10%
Kenya	1	15%	15%	Project documents
Malaysia	5	8 - 10%	10%	Project documents
Nigeria	1	20%	15%	Adjusted for comparability
Peru	2	12 - 14%	12%	Project documents
Qatar	1	10%	10%	Project documents
South Africa	4	10 - 13.75%	10%	Project documents
South Korea	4	0 - 15%	8%	Project documents

(*): The project sample has been constructed to be balanced by project types and not necessarily by host countries. For example, there are very few projects from LDCs with reliable financial information. Similarly, Indian projects have a tendency to exclude the investment analysis from their project documentation, and in those projects with investment analysis, the variance of the resulting costs is very high and thus we preferred to leave these data out of the sample.

To obtain the abatement cost per tonne of CO_2e emissions reduced, we take in the denominator the amount of emission credits the project expects to generate over its lifetime (thus, over 10 or over 21 years, depending on the choice of crediting period by the project developer), discounted with the same financial discount rate as the one used for the costs. In this way we obtain constant emission credit costs.[27] CDM transaction costs have not been included in the estimations. Even though

[26] Project developers have an incentive to manipulate their figures and try to show low revenues, so that the project appears financially unattractive, which is a requisite for being considered additional.

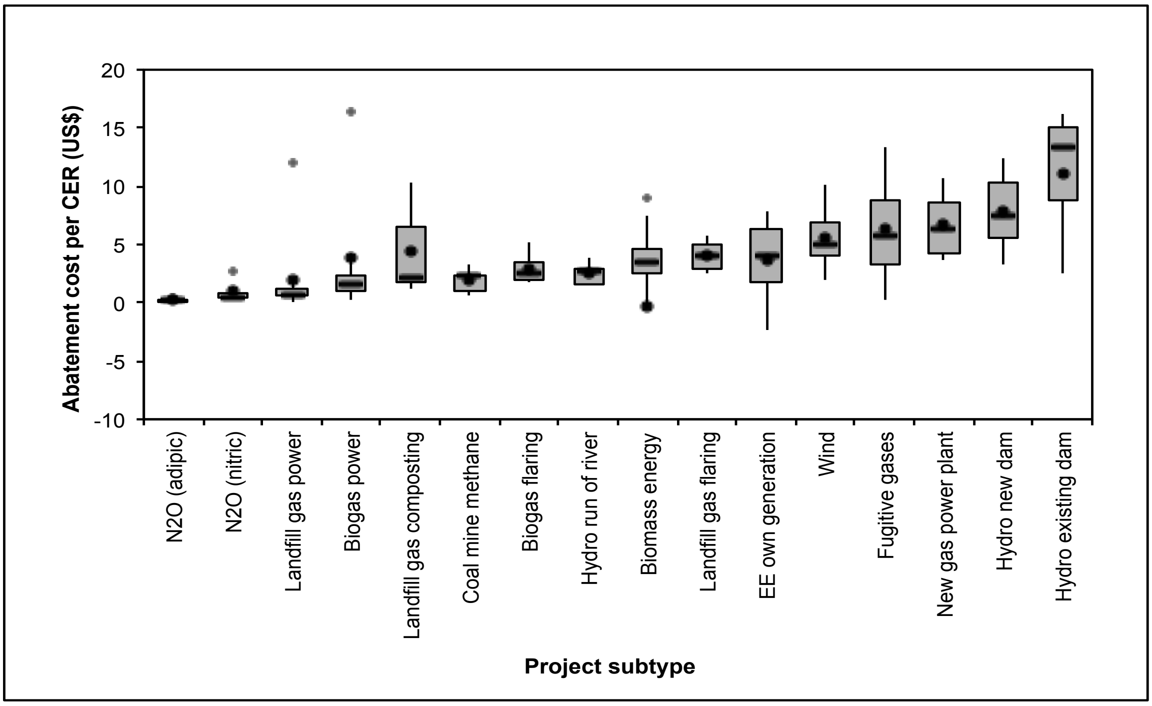
[27] In a previous version of this study, we made the cost estimations on the basis of the full (non-discounted) amount of emission credits, but just from the first crediting period (this is, over 10 or over 7 years). This approach was chosen due to the uncertainty involved in crediting period renewal, and the resulting high likelihood that project developers calculated

transaction costs represent a significant sum, especially for small-scale projects, we have opted for simplifying the calculations in this assessment.

Another important consideration in the abatement cost calculations is the treatment of the baseline costs. The baseline is generally conceived as the situation without project. This situation without project may imply a different investment or the continuation of the current situation without a new investment. Many energy-related CDM projects argue that their baseline is the status quo, the continuation of the present situation without investment. In some cases, this implies expenses, such as buying energy from the grid or buying coal. In these cases, avoiding or reducing these expenses is considered as revenue for the project and is included in the abatement cost calculations. But in some other cases, the baseline situation does not imply costs for the project owner, and thus is not included in the calculations. In very few cases, the baseline represents a new investment, e.g. in a new fossil fuel-based power plant. Avoiding this investment is again considered as a saving achieved by the project.

Figure 4.1 and Figure 4.2 show box plots of the estimated abatement costs of the projects in the sample, both with the original financial discount rates and with the financial discount rates standardized by us, respectively.

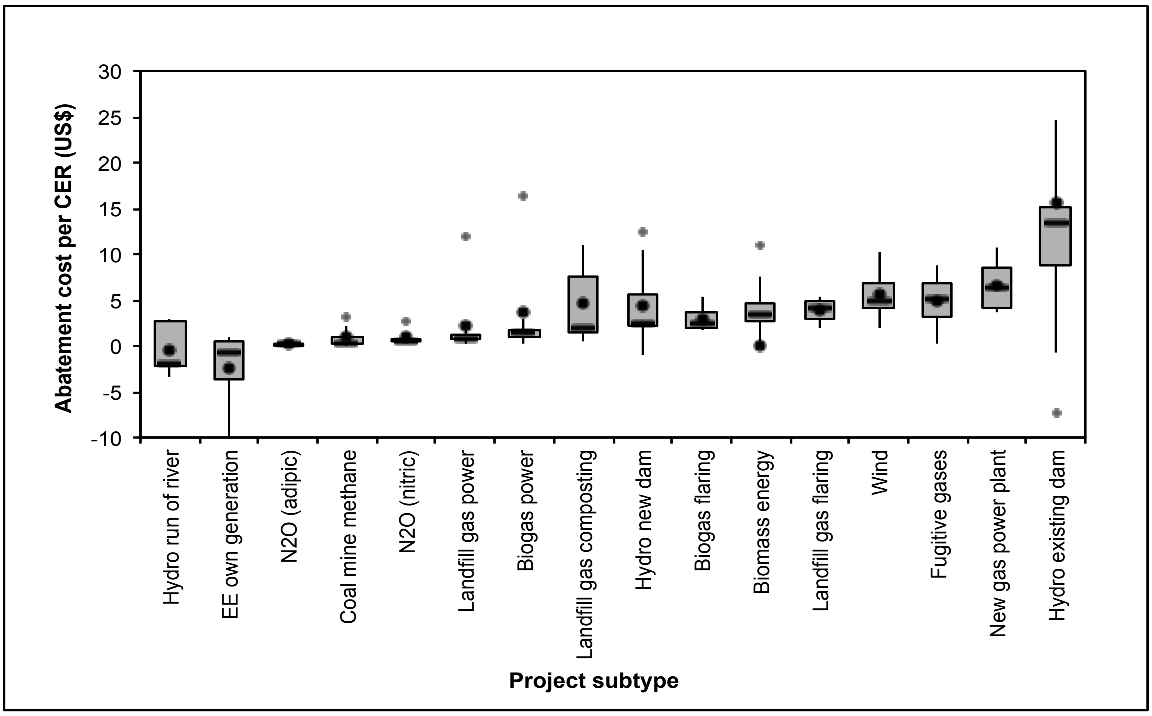
Figure 4.1: Abatement cost per emissions credit by project subtypes with original financial discount rates (US$)



Note: Calculation based on projects' net present value and time-discounted amount of emission credits over their lifetime. 'EE' means energy efficiency.

their profitability on the basis of the emission credits from just the first crediting period. However, time-discounting also controls for this uncertainty and leads to a clearer interpretation of the cost estimates. The results from both cost estimation approaches do not differ substantially.

Figure 4.2: Abatement cost by project subtypes with standardized financial discount rates (US$)



Note: Calculation based on projects' net present value and time-discounted amount of emission credits over their lifetime. 'EE' means energy efficiency.

In these results, it is clear that even within project subtypes there is still a high variability in cost estimations, and that thus these estimations need to be used with care. However, even with this high variability, our results reproduce very closely the range and ranking of costs reported in other abatement cost studies (US EPA 2006; Vattenfall 2007; Wetzelaer et al. 2007): Methane and industrial gas reduction projects are cheaper than CO_2-reduction projects, basically due to the higher global warming potential of these other gases; renewable energy projects, specifically wind and hydro projects including the construction of dams and also natural gas power plants are among the costlier ones. All this is consistent with other abatement cost curves and supports our results. The abatement costs of most of these CDM projects are below US$ 13, which is an indication that the emission credit income could make them attractive.[28] The standardization of discount rates results in important shifts in the cost estimation for some technologies, in particular for energy efficiency in power generation. This results from the fact that even if all the energy efficiency projects analysed are located in China, they apply very different financial discount rates, even very high ones (from 8.5 to 15%). In Figure 4.2, Chinese discount rates were standardized at a 8% level (as most projects

[28] According to the monthly newsletter 'CDM Highlights' issued by GTZ, CDM credit prices fluctuated between US$ 12 and US$ 33 in the spot market during 2008 and 2009, with an average of US$ 20.7. The World Bank's *State and Trends of the Carbon Market* (Kossoy and Ambrosi 2010) cites an average price of $12.7 per CER in the primary market during 2009. While it is difficult to choose between primary and secondary prices as the correct threshold for defining a cheap abatement option (as project developers in different countries have different CER selling strategies), the conclusion remains unchanged if the $12.7 or the $20.7 average price is used. The conclusion also remains unchanged if it is considered that CDM transaction costs should be added to the pure abatement costs before assessing the financial attractiveness of the project.

located in China convincingly argue that this discount rate is reasonable for the country in the energy sector), thus resulting in a shift downwards for the estimated costs of the energy efficiency projects.

The variability of costs within project subtypes stems from various factors. Above we have already discussed the impact of project lifetimes and financial discount rates on the cost estimations, and these figures can be manipulated easily to make projects appear non-attractive. However, there are also large differences in the technologies used within project subtypes. For example, biogas power projects can consist of a sophisticated bioreactor, or just of a plastic membrane covering the already existing anaerobic lagoons, which allows to capture the methane. Further, biodigesters can be imported or can be manufactured domestically, which will also have an impact on costs. Biomass projects include energy generation from rice husks, bagasse, palm oil residues, forest residues, and a variety of other agricultural or industrial by-products. Energy efficiency projects take place in cement, steel, chemical, petrochemical and other industries and can encompass different efficiency measures. Hydroelectric projects have very different sizes, and smaller ones (among those including a dam) typically imply higher abatement costs. Finally, different countries can have different cost structures, with differing energy prices, taxes or financial incentives for specific technologies that may have an impact on overall abatement costs. Ideally, we should have a different project sample for each host country and estimate country-specific CDM abatement costs, however, due to time constraints and to the fact that most countries still have too few registered CDM projects, this has not been possible.

Another important point to discuss in these results is the existence of CDM projects with net negative abatement costs. If we consider the financial discount rates used by the project proponents in the project documentation, these negative-cost projects are only two, just one biomass energy and one energy efficiency project. The biomass project substantiates its additionality through a barrier analysis, but includes an annex showing the cash flow of the project with a positive Net Present Value. The energy efficiency project substantiates additionality through the comparison with an alternative project: even if the CDM project activity has a positive NPV, the alternative has an even better one, so that it would be the preferred course of action.

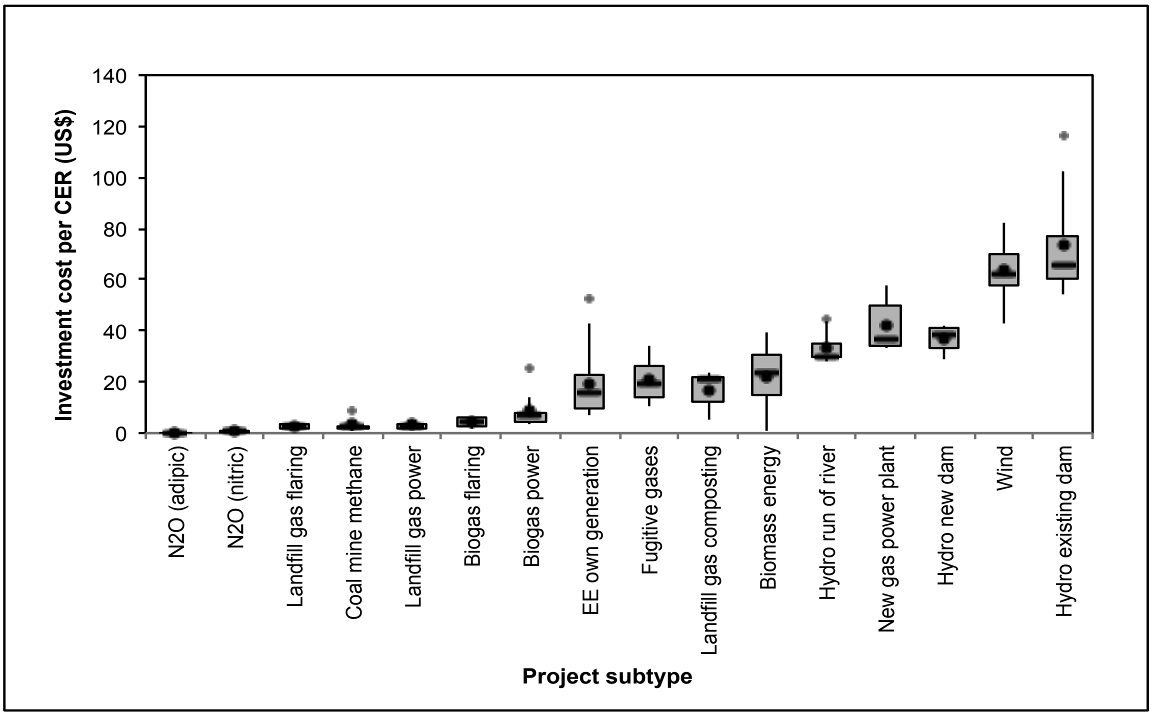
If we take country-standardized financial discount rates, also some other projects have negative costs, and surprisingly, run-of-river hydroelectric projects and own-generation energy efficiency projects even have a mean negative cost. Our whole sample in these project categories is from China, where most projects originally used 8% as financial discount rate, while some hydro projects used 10% and energy efficiency ones even higher rates. We standardized all Chinese financial discount rates to 8%, on the grounds that most energy-related projects in this country use this figure. But then, half of the energy efficiency projects and all hydro projects that originally took 10% financial discount rate become financially attractive. MAC curves from the literature show that many energy efficiency projects have negative abatement costs and are thus theoretically financially attractive (e.g. Vattenfall 2007). The reason why these project opportunities are not realized is that they face important market imperfections (information asymmetries, misaligned incentives, lack of priority, and financial risks). We thus believe that the standardized costs most likely reflect standard engineering costs of such projects, while the non-standardized ones may reflect different perceptions about project risks.

Up-front investment costs

One of the main barriers for investing in infrastructure in Least Developed Countries and Sub-Saharan Africa is the availability of up-front financing. The main costs of renewable energy projects are investment costs, as they do not bear annual fuel costs. Whether CDM revenues can cover a substantial amount of the up-front investment costs could constitute an important factor in the decision to undertake a project or not.[29] For these reasons, we have repeated our empirical estimation using total investment costs per CER. The results are shown on Figure 4.3.

Here again, we observe a high variance in the investment costs of the different project subtypes. As in the case of the full abatement costs, this reflects the variability in technologies used, their origin, and the project sizes. On the other hand, the sequence of project types according to investment costs is again consistent with the previous assessments: projects involving new infrastructure, such as large renewable energy projects or gas power plants have larger investment costs. Projects involving a relatively small change in a process, such as N_2O reduction, landfill or biogas projects have smaller costs.

Figure 4.3: Investment cost per emissions credit by project subtypes (US$)



Note: Calculation based on projects' total investment costs and time-discounted amount of emission credits over its lifetime.

[29] In this context, again the consideration of which credits are considered in the cost calculations (just pre-2012 credits, those expected from the first crediting period, or those from all crediting periods) is critical for investment decisions. For similar reasons as above, the discounted amount of credits projected for the whole project's lifetime is used in these calculations.

4.4.4 CDM emission abatement potentials

There are few comprehensive studies on the emissions abatement potential in developing countries. Notable exceptions are the studies by Wetzelaer et al. (2007), Bakker et al. (2007) and, more recently, De Gouvello et al. (2008).

Based on data from climate mitigation studies in 30 countries, Wetzelaer et al. (2007) developed an abatement cost curve for the non-Annex I region in the year 2010, focusing mainly on CO_2 and to a lesser extent on CH_4 emission reductions. The study concluded that the total abatement potential for the whole non-Annex I region in the year 2010 amounts to about 2 $GtCO_2e$/yr at a price of US$ 50/tCO_2e or less. About one third of this potential is expected to be achievable at negative or zero incremental costs. Approximately 1.7 $GtCO_2e$/yr appear feasible at costs of up to US$ 4/tCO_2e, including transaction costs. 66% of the total abatement potential was found in China (37%), India (23%), Brazil (4%) and South Africa (2%) (Wetzelaer et al. 2007).

Building on the above-mentioned study, Bakker et al. (2007) tried to find the market potential of abatement options in non-Annex I countries by 2020. Their study differentiates between technical abatement potential (reductions that can be realized based on technical and physical parameters), economic potential (reductions that can be realized below a certain cost level) and market potential (reductions that can be realized considering other barriers). Bakker et al. (2007) updated and completed the abatement cost curves, by including information from new country studies, extrapolating them from 2010 to 2020, and adding new technology options (carbon capture and storage, and forestry) and non-CO_2 GHGs. In order to find out the market emissions reduction potential, they included a scenario-based analysis of the impacts of different CDM-related factors on the abatement potential: the eligibility of technologies under the CDM, the future application of the additionality criterion, the success of programmatic CDM, the investment climate and institutional environment in the host countries, and the existence of non-financial barriers related to the uptake of technology. In the scenarios, only the abatement potential of the options was varied, not the cost. Accounting for the uncertainties related to eligibility decisions, additionality criteria, programmatic CDM and technology adoption, the market potential for CDM projects was estimated at 1.6 - 3.2 $GtCO_2e$/yr at costs up to 20 €/tCO_2e in 2020.

The study by De Gouvello et al. (2008) looked at the abatement potential in the energy sector in Sub-Saharan Africa, using the existing CDM methodologies to identify technologies that could promote GHG emission reductions and at the same time support energy development in the region. They thus built a bottom-up inventory of clean energy projects applying 22 technologies in 44 countries in SSA, which includes over 3200 projects, among them 361 programmes of activities. These projects would amount to more than 170 GW of additional power-generation capacity, which is more than twice the region's current installed capacity, providing about four times the region's current modern-energy production. The resulting GHG emissions reduction potential would total about 740 million tCO_2 per year, and would be mainly related to the biomass sector.

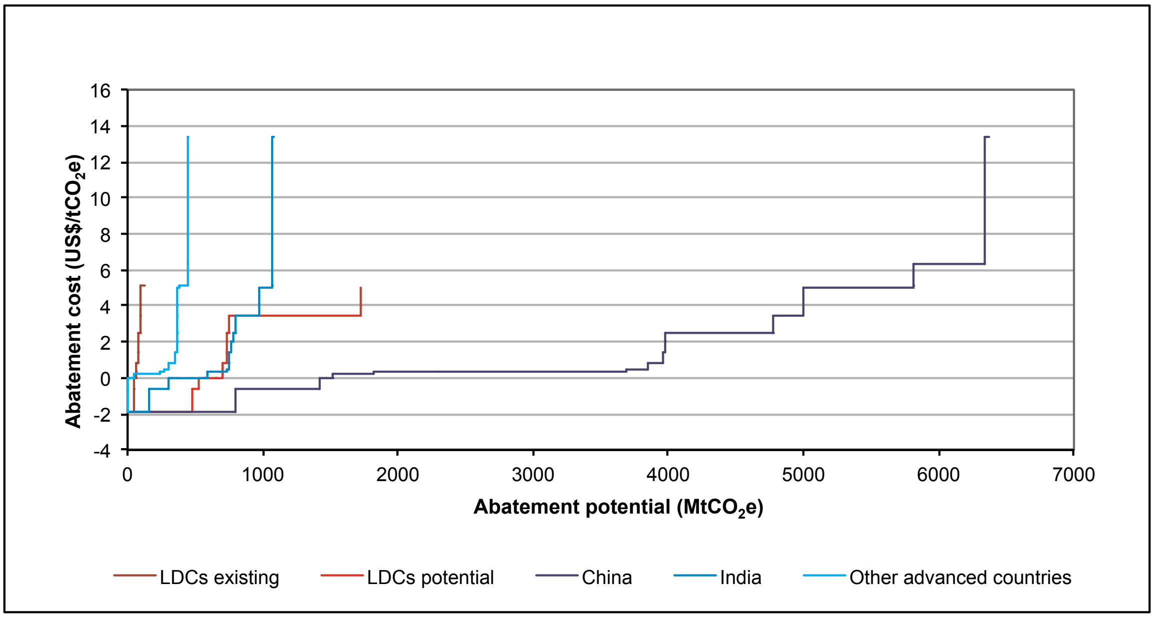
This study also included estimated investment costs for many of the technologies found, but did not include a full economic analysis. Even investment data were unavailable for projects representing 36% of added power-generation capacity and 21% of emission reductions (2008).

4.4.5 Costs and potentials – MAC curves

Combining the information on standardized abatement costs for emission credit generation and CDM potential in different countries or regions, we obtain our basis for the comparison of CDM competitiveness: MAC curves. Figure 4.4 shows abatement cost curves for China, India, LDCs, and a group of selected high-income high-emissions Asian countries (Qatar, United Arab Emirates, Singapore, South Korea, Israel) without discounting the emission credits.

As abatement costs we use the median standardized abatement cost obtained for each project sub-type from our sample. HFC-23 reduction projects, very prominent in China and India, typically lack financial data in the project documentation, as their additionality (the main reason why financial information is disclosed) is guaranteed due to the fact that the only income stream for these projects is the sale of emission reduction credits. For this type of projects, abatement cost estimations from secondary sources (Harnisch and Hendriks 2000; UNEP TEAP 2002; Jimenez 2005) have been used.

Figure 4.4: Abatement cost curves without emissions credit discounting



Sources: Cost data from Project Design Documents; for HFC-23 projects from Harnisch and Hendricks (2000); UNEP TEAP (2002); Jimenez (2005). Potentials from UNEP Risoe Centre (2009) and De Gouvello et al. (2008). Own calculations.

The abatement potential is estimated simply by summing up all emission reductions projected to be achieved by all projects in the CDM pipeline as of end of 2008 (UNEP Risoe Centre 2009). This is a very approximate estimate. On the one hand, it does not include CDM projects not yet submitted for validation, so the potential may increase over the following years. On the other hand, it includes projects that may fail validation or registration, whose potential will thus not materialise. Finally, this estimation does not take into account the fact that credit issuance is for most project types actually less than the estimations provided in the project documentation. However, as these sources of bias are present in CDM projects over all host countries, we deemed these figures to be precise enough for our comparison.

For the group of Least Developed Countries, we include two estimations. The first one ("LDCs existing") is, as above, the sum of all emission reductions projected from the current CDM pipeline in this region. The second estimation ("LDCs potential") additionally includes the abatement potential estimated by De Gouvello et al. (2008) for the LDCs in Sub-Saharan Africa, excluding the potential from biofuel projects, which so far do not have any approved methodologies. This provides an optimistic estimation of the abatement potential in these countries, which could be achieved if the technical, financial and institutional conditions were substantially improved.

It should be noted that these curves include project types without cost information. These appear at present at the left end of the curves, as having zero abatement costs. The projects without cost information represent 1.7% of the abatement potential in China, 8.6% in the advanced host countries, 7.3% in LDCs existing, 7.9% in LDCs potential and 26.5% in India. In the Indian case, about one third of this potential comes from supply-side energy efficiency projects, for which abatement costs should be similar that those in own generation energy efficiency projects, which have net negative costs when standardizing the financial discount rates. Unfortunately, the financial information for supply-side energy efficiency is either non-existing or not very credible in the project documents analysed. While this inclusion might provide the wrong impression of a large quantity of low-cost (or zero-cost) project options, we opted for not omitting these data from the curves as they allow for a more realistic picture of the overall abatement potential.

4.5 Empirical assessment of the effect of discounting in selected countries

In this section we include the effect of two possible discounting schemes on the CDM abatement cost curves of the selected regions and countries.

4.5.1 Discounting scheme 1

We use per capita GDP and per capita emissions as the criteria for defining the discount factor for emission reductions, which captures the principles of capability to pay and responsibility towards climate change. Each country's GDP per capita and emissions per capita are compared to the average values for the whole world, using the data from IEA (2007a). Both proportions are given the same weight, as both principles are equally important and are not directly correlated. Thus, the discount factors[30] are calculated as indicated in Equation 4.2:

$$\text{Discount factor} = 1 - \frac{2}{\dfrac{\text{Country's emissions/cap}}{\text{World average emissions/cap}} + \dfrac{\text{Country's GDP/cap}}{\text{World average GDP/cap}}}, \quad (4.2)$$

Negative discount factors are not permitted, since this would imply issuing more than one emissions credit per tonne of emissions reduced. Table 4.3 shows the resulting discount factors for some countries included in this study. See Michaelowa (2008b) for a more detailed description of this discounting scheme, including the calculations for other countries.

Table 4.3: Discount factors for the emission credits

Host country	GDP/cap (PPP, 2000 US$)	Emissions/cap (tCO_2e/year)	Discount factor under scheme 1	Discount factor under scheme 2
World	8492	4.22	-	-
Qatar	38556	44.90	87%	93%
United Arab Emirates	22715	24.37	76%	88%
Singapore	26401	9.93	63%	82%
Israel	23022	8.65	58%	79%
South Korea	19837	9.30	56%	78%
China	6012	3.88	0%	39%
India	3072	1.05	0%	0%
Zimbabwe	1813	0.79	0%	0%
Cambodia	2503	0.27	0%	0%
Yemen	827	0.89	0%	0%
Mozambique	1105	0.08	0%	0%
Tanzania	662	0.11	0%	0%

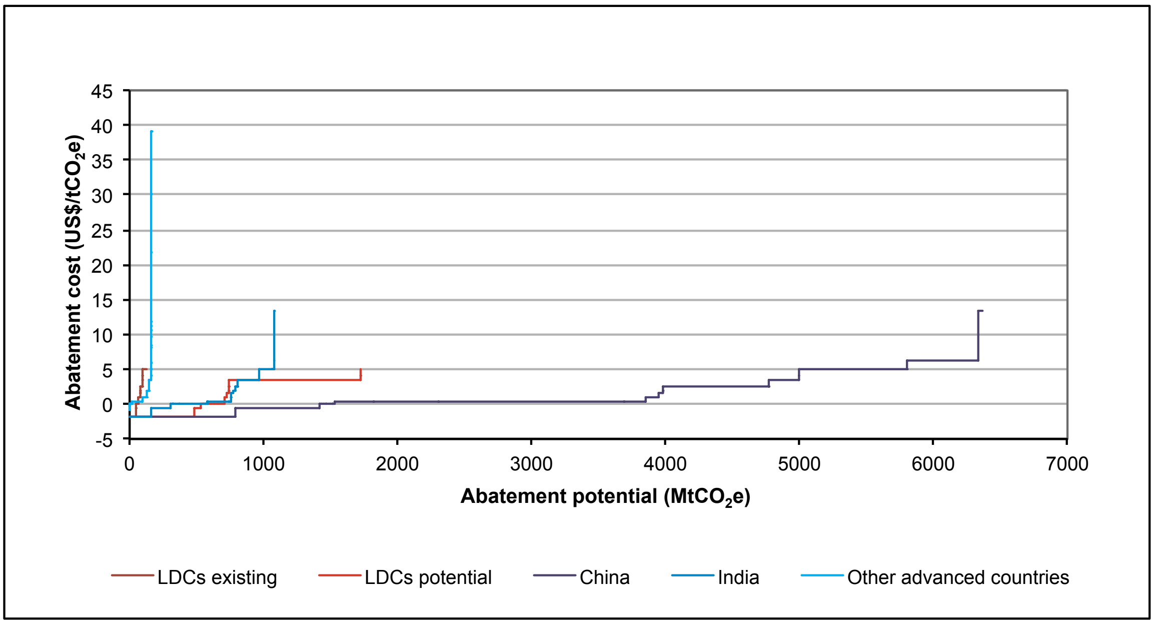
Source: IEA (2007a). Own calculations.

With this scheme, of our selected countries only those in the "Other Asia" group (Qatar, United Arab Emirates, Singapore, South Korea, Israel) are affected by the discounting. As can be seen when comparing Figure 4.5 with Figure 4.4, their abatement cost curve shifts to the left and upward as a result of the increase in costs per credit and the reduction in credit generation potential. Further, with this discounting scheme about 95% of the projects in the current CDM pipeline of these advanced countries would still be feasible with credit prices up to 20 US$ on average. Only a hydroelectric project in South Korea and a project for the reduction of fugitive natural gas emissions

[30] Discount factors are to be understood as the percentage of emission reductions that is not credited. For example, a 30% discount factor would imply that only 70% of the measured emission reductions receive emission credits.

in Qatar would be lost. While projects in advanced countries become less competitive, current projects in LDCs are still non-significant at a global level, and future potential is still small compared to the Chinese pipeline. This shows that discounting cannot serve as a "magic bullet" that suddenly frees up a large CDM potential. Other barriers such as availability of domestic capital and skilled workers are so entrenched that the revenue from credit sales cannot remove them. CDM alone cannot overcome the legacy from decades of failed policies – even if getting some advantages compared to projects with a more development-oriented governance.

Figure 4.5: Abatement cost curves with discounting scheme 1



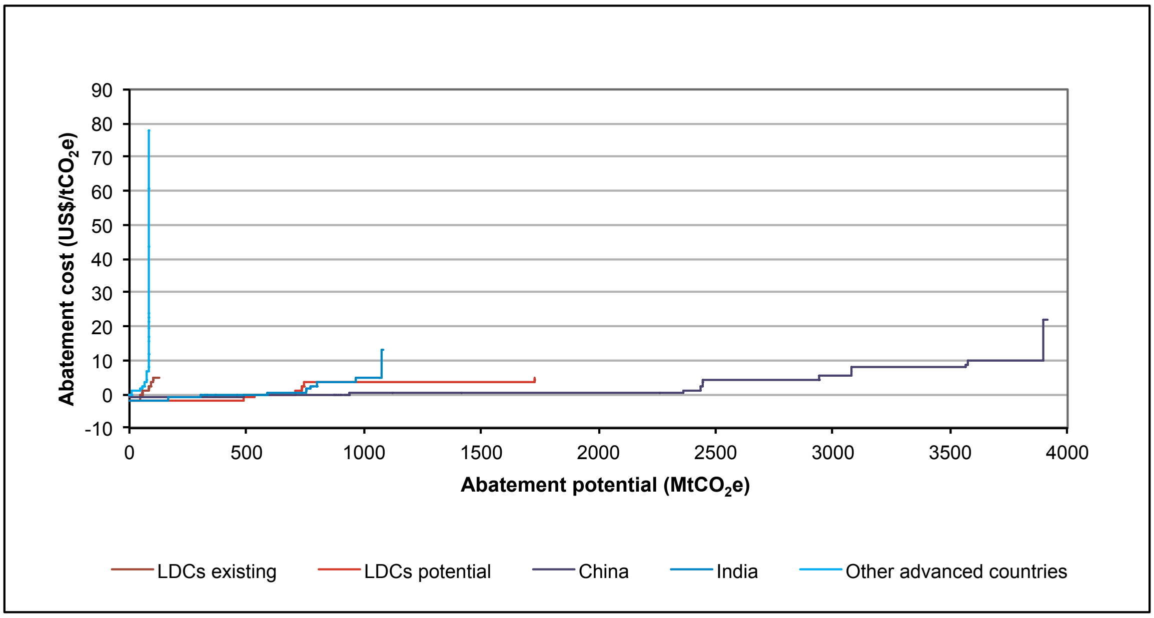
Sources: Cost data from Project Design Documents; for HFC-23 projects from Harnisch and Hendricks (2000); UNEP TEAP (2002); Jimenez (2005). Potentials from UNEP Risoe Centre (2009) and De Gouvello et al. (2008). Own calculations.

4.5.2 Discounting scheme 2

In this case, the discounting of emission credits is again based on an index composed of per capita GDP and per capita emissions, taking as basis the world average of both indicators. But discounting starts already when the country reaches half of the world's average emissions and GDP. This scheme is designed to include China among the countries affected by discounting. Overcrediting is again not possible. See Table 4.3 for the resulting discount factors and Michaelowa (2008b) for a further description of this discounting scheme.

Under this scheme, both China and Other Asia are affected by discounting. Figure 4.6 shows the result: while the potential in the Asian tigers is greatly reduced and the costs rise sharply, making a larger portion of its abatement potential uncompetitive (now also a couple of wind energy projects become infeasible, with costs slightly over 20 US$), still most of China's potential – albeit reduced and more expensive – remains competitive with credit prices below 20 US$. Under these conditions, all CDM projects in the current pipeline in LDCs have smaller abatement costs than those in advanced countries. Their volume is however still unimportant. There is some hope if we look at the "LDCs potential" curve: assuming the barriers are overcome and these projects are implemented, their potential reaches half of the Chinese one, with costs below 5 US$/credit. This shows that once the purely technical potential becomes available due to the mobilization of capital and removal of political barriers the higher credit revenue compared to other CDM host countries could make the difference. Countries that have reformed their policies and enabled the creation of domestic capital could use the CDM as lever to accelerate development.

Figure 4.6: Abatement cost curves with discounting scheme 2



Sources: Cost data from Project Design Documents; for HFC-23 projects from Harnisch and Hendricks (2000); UNEP TEAP (2002); Jimenez (2005). Potentials from UNEP Risoe Centre (2009) and De Gouvello et al. (2008). Own calculations.

4.6 Conclusions

Country-based discounting will of course have an impact on the competitiveness of individual CDM host countries in the carbon market, however, as shown above, this impact will depend on emissions abatement potentials and costs in the country.

Discounting could become an interesting instrument for incentivizing advanced developing countries to leave the CDM and engage in other farther-reaching climate-related commitments, as a result of the steep credit cost increases that a discounting factor might generate.

However, this study shows that even under discounting schemes designed to include China, Least Developed Countries remain unimportant in terms of abatement potential from the CDM pipeline.

While there is a theoretically large abatement potential to be exploited in Africa, its materialization requires overcoming financial, technical and institutional barriers. Given the large cheap potential in China and other countries, it is unlikely that discounting on its own will provide sufficient financial incentives to achieve this. But once countries start removing barriers, the CDM incentive could play a non-negligible role in development. Nevertheless, even under the optimistic scenario, where the financial, technical and institutional barriers in these countries are overcome and a larger potential becomes feasible, the larger abatement potential and the cheap abatement costs in China and other more attractive host countries will be harvested first.

Thus, discounting would only marginally contribute to enhance the competitiveness (in terms of abatement potential and costs) of LDCs within the CDM market.

5. DOES THE CDM DISCOURAGE EMISSION REDUCTION TARGETS IN ADVANCED DEVELOPING COUNTRIES? AN ANALYSIS OF THE LOW-HANGING FRUIT ISSUE[31]

'As with perishable produce, low hanging fruit will rot, if they are not harvested. Therefore: the rule of "sell them or smell them" is true for CO_2-credits, too'

(World Bank 2003, p. 32)

'The commission is saying we must watch out that the off-setting mechanisms (such as the current CDM) do not take away the low-cost options for developing countries. The commission does not want these countries to be left with only very high cost ways of reducing emissions […].'

(Tomas Wyns, CAN Europe, quoted by Garside 2009)

'Lower cost mitigation opportunities (low hanging fruits) should be left for the developing countries, as part of their voluntary endeavor to contribute to the global mitigation effort.'

(Government of Saudi Arabia 2011, p. 80)

'Under the current market based paradigm, developed countries that have exhausted their own low-cost mitigation options may rely on low-cost mitigation options in developing countries to meet their obligations. This renders these options unavailable to developing countries forcing them to rely on remaining high-cost options.'

(Government of Malaysia 2011, p. 12)

5.1 Introduction

The previous two chapters looked into shortcomings of the CDM that affect its ability to encourage emission reductions in the less developed countries, and analysed the potential effects of measures that have been proposed to address these shortcomings. The following two chapters will be dedicated to the role of the CDM in those countries in which it has been more successful, i.e. the more advanced developing countries. The focus will be on aspects of the CDM that influence its ability to generate positive incentives for generating emission reductions – beyond offsetting – in these countries.

One of the concerns that have surrounded the CDM since its establishment and even until today – as can be seen form the quotes above – is the fear that engaging in CDM projects would imply

[31] This chapter is based on Castro, Paula (2011), 'Does the CDM discourage emission reduction targets in advanced developing countries?', *Climate Policy*, vol. 12, no. 2, pp. 198-218.

selling off developing countries' cheap emission reduction options (the so-called "low-hanging fruit") to industrialized countries, with the result that developing countries would have to invest in more expensive measures to meet their own future reduction targets.[32] While the CDM is a cost-containment mechanism and as such is supposed to target the cheap emission reduction options, the low-hanging fruit focus of the CDM has also been criticized from a developed-country perspective, on the grounds that the subsidy granted by the mechanism to very large, low-cost projects is disproportionately large compared to the cost of implementing the emission reductions (Wara, 2008). Despite these concerns and criticisms, the CDM has grown successfully, and its largest host country, China, is one of those that were initially most sceptical of it (Tangen and Heggelund 2003; Bang et al. 2005).

In the international negotiations towards a new climate regime post-2012, there is considerable pressure on fast-growing developing countries to take up some kind of emission reduction commitments. Firstly, it is now recognized that future global emissions reduction targets need to be much more ambitious than the Kyoto target for avoiding dangerous climate change. Secondly, some large and fast-growing developing countries already emit such high levels of greenhouse gases (GHGs) that their participation is regarded as crucial for avoiding dangerous climate change (Bang et al. 2005; Höhne et al. 2007; Gupta et al. 2007a; Parry et al. 2007; WRI 2008).[33] Thirdly, concerns about the impacts of climate policy - on a country's competitiveness in the global markets and the likelihood that energy-intensive industries migrate to countries without emission reduction targets - have been prominent in research and policy debates (Hourcade et al. 2001; Baumert and Kete 2002; Cosbey 2005; Barker et al. 2007; High Level Group on Competitiveness, Energy and the Environment 2007). All these concerns have led to increasing demands by industrialized countries that advanced developing countries take up emission reduction commitments.

Developing countries, however, oppose committing to reduction targets. Their main arguments are the historical responsibility of industrialized countries for existing carbon concentrations in the atmosphere; the negative impact that reduction targets might have on their development, poverty alleviation and growth expectations; and notions of fairness in the amount of emissions a person is allowed to generate in developing countries as compared to industrialized ones. For detailed accounts of different countries' positions in the international negotiations towards new climate commitments, see Bang et al. (2005) and, more recently, Höhne et al. (2007) and WRI (2009).

The CDM experience plays a role in these negotiations as well. Some developing countries and environmental Non-Governmental Organizations (NGOs) consider the CDM to be a means for industrialized countries to shift their emissions reduction responsibility to other countries. Based on its project-by-project nature, critics argue that it creates disincentives for developing countries'

---

[32] See Narain and van't Veld (2008) for a review of occasions when the low-hanging fruit issue was discussed in the Kyoto negotiations.

[33] Recent calculations suggest that China is now the largest CO_2 emitter in the world, surpassing even the USA (MNP (Netherlands Environmental Agency) 2008; IEA 2010a). However, per-capita emissions in this and other large developing countries are still very low in the global ranking.

governments to pass climate-friendly legislation.[34] Due to the large financial flows achieved by the CDM, industrialized countries feel uncomfortable that the desire to continue receiving these funds is itself a reason for advanced developing countries not to take more ambitious climate change mitigation actions (US Government Accountability Office 2008; European Commission 2009). Moreover, the costs of mitigation actions, coupled with the above-mentioned fear that the CDM has already captured the cheapest ones, make developing countries even more unwilling to commit.

In this chapter, I test this last argument empirically, thus contributing to the discussion on the role of offset mechanisms in achieving global GHG emission reductions. So far, most of the research on this so-called low-hanging fruit claim has been theoretical and model-based, and thus no empirical evidence for its validity has yet been presented. With the large number of CDM projects in the current portfolio, this is now possible.

The existing literature on the low-hanging fruit claim is first reviewed. The approach for testing this claim using marginal abatement cost curves is then detailed and the emissions abatement cost of CDM projects using the financial information provided in their Project Design Documents (PDDs) is estimated. A dataset of projects, technologies, estimated costs and expected amount of emission reductions is built for eight CDM host countries and summarized in the form of CDM-specific abatement cost curves. These curves are compared with existing abatement cost curves from the literature, in order to determine whether only or mostly the cheapest abatement options are being captured by the CDM. Conclusions for the CDM, the low-hanging fruit argument and its relevance for the ongoing climate negotiations follow.

5.2 Literature review

The low-hanging fruit issue – also known as the "sold-out" hypothesis, the "cherry-picking" or the "cream-skimming" problem – was already a discussion topic during the negotiations that led to the implementation of the CDM. It is the claim that developing countries will be worse off after selling their cheapest abatement options (the low-hanging fruits) to industrialized countries through the CDM, because they will have to invest in more expensive options later, when they assume own emission reduction targets.

So far, only theoretical analyses of the low-hanging fruit problem have been available in the literature. The results of these studies imply that the existence of a low-hanging-fruit problem basically depends on the evolution of carbon credit prices, the way in which future abatement commitments for developing countries are set, whether CDM projects are developed unilaterally or

[34] In order to be registered, CDM projects need to demonstrate that they would not have happened without support from the CDM (the additionality rule). Thus, if in country X there is a piece of legislation that mandates, for example, the use of energy saving lamps, then country X cannot propose a CDM project to replace incandescent bulbs with energy saving ones. The additionality rule discourages countries from passing climate-friendly legislation, because they do not want to lose the potential revenues from possible CDM projects. To avoid this perverse incentive, the CDM authorities created the E+/E- rule in November 2005, which states that climate-friendly policies passed after the year 2001 are not to be counted towards the additionality constraint of CDM projects.

bilaterally, the market power of the participating countries and the possibility to bank credits from one commitment period to the next (Olsen and Painuly 2002; Akita 2003; Bréchet et al. 2004; Germain et al. 2007; Narain and van't Veld 2008).

But several more general characteristics of the climate regime give shape to this interpretation. First, it assumes a necessary condition that developing countries, especially the more advanced ones, will eventually “graduate” and commit to their own GHG emission reduction targets (Akita 2003). This has been one of the most controversial debate topics in the international negotiations towards a post-2012 agreement. While the Kyoto Protocol presupposes such a transition and industrialized countries are trying to push for it, the existing rules do not explicitly include it, and most developing countries are currently against it.

Second, the availability of CDM project options is not only influenced by the cost of the abatement measures, but is also constrained by financial, technical and institutional barriers in the host countries and by the CDM rules themselves. In particular, the high CDM transaction costs and cumbersome registration procedures may prevent attractive abatement options from accessing the mechanism (especially if they are small-scale). While this situation is expected to improve with new CDM modalities, it is likely that some of these cheap abatement options will contribute to the host country’s own reduction targets in the future. This also applies to project types that are currently not accepted in the CDM, such as avoided deforestation and many other land use change projects, and the use of nuclear energy. Further, only those projects considered additional can be registered as a CDM. If currently expensive mitigation options become cheaper, they might no longer fulfil the additionality criterion – if one uses low-hanging fruit terminology, the fruit starts to ‘rot’ (World Bank 2003, p. 32).

Furthermore, new emissions abatement options may appear and become cheaper in time as technology evolves and as economies grow. The pool of abatement options is thus not a static one but may grow in the future, especially in developing countries.

Finally, there is an international market for carbon reduction certificates. Assuming a continuation of the current regime, even after a country graduates, there will be other developing countries still under the CDM system, which may continue to deliver cheaper carbon credits (Narain and van't Veld 2008). Similarly, as abatement options in some countries become scarce or more expensive, other countries now under-represented in the CDM will become more mature and enter the market more actively.

5.3 The low-hanging fruit issue

To model the low-hanging fruit issue, Rose et al. (1999) draw on the theory of resource exhaustion, whereby there is a resource stock (carbon emission mitigation options) that is exploited and gradually depleted, which results in rising costs of implementation for emission mitigation projects over time. This approach is followed here and it is assumed that part of the stock of emission reduction options in developing countries is captured by the CDM. By comparing the complete stock to the portion captured by the CDM, conclusions are drawn on whether the low-hanging fruit argument holds.

This approach implies a strong simplification of reality, as it does not take into account the carbon market dynamics that, according to the literature, influences the availability of emission reduction options. Both emissions trading and banking – the possibility to save carbon credits earned today for using them in a future period – relax the problem of exhaustion of emission reduction options, as they increase flexibility in achieving reduction targets. Economic growth and technological change will make new emission reduction options appear, so that the abatement stock is replenished. Learning effects and technology diffusion will make these new emission reduction options become cheaper in time, so that there will be new low-hanging fruits to pick.

However, at a given moment in time, it can be assumed that the stock of abatement options available is fixed. As a result, our test of the low-hanging fruit problem relies on two hypotheses:

- Size hypothesis: The larger the portion of the country's mitigation potential (measured in tCO_2e) that has been captured by the CDM, the more likely there is a low-hanging fruit problem.
- Cost hypothesis: The larger the portion of the country's *cheap* emission reduction options that has been captured by the CDM (measured in tCO_2e), the more likely there is a low-hanging fruit problem.

If the CDM is not exhausting the stock of abatement options under the extreme assumption of no dynamics, the actual situation must be even better, because the stock will grow in the future. Thus, this assumption leads us to a strong, robust conclusion.

Our conceptualization of "cheap emission reduction options" relies on the carbon market: "cheap" is defined as all those emission reduction options whose abatement costs are below the average carbon market price for CERs. This is in line with the notion that the market will influence the choice of emission reduction actions: if the market price does not compensate for the cost of mitigation, then it is not financially attractive to engage in this action, and it is preferable to trade carbon credits in the market.

5.4 Data and methods

5.4.1 CDM cost data

The analysis in this chapter relies partly on an extended version of the self-compiled database on CDM project costs described in Chapter 4, and on the construction of MAC curves for six of the most important CDM host countries. Accordingly, CDM project information was obtained from the UNEP Risoe Centre's CDM pipeline (UNEP Risoe Centre 2010) and detailed cost data were compiled from the documentation available for each CDM project on the UNFCCC website, which often includes a financial analysis in the section about demonstration of additionality.

While this is the only CDM-specific source of financial data that is easily available for compiling a comprehensive dataset, there is a risk of selection bias because information comes only from those projects choosing to use a financial analysis for additionality demonstration. Indeed, one could think that it is precisely the projects using the barrier analysis which are the low-hanging fruits, and that they do not present their financial data because they are so cheap that they would not pass the additionality test if they did. This suspicion is shared by the CDM regulators, as can be seen in the proposal by the CDM Methodology Panel to enhance the barrier test for projects that are likely to have high revenues (CDM Methodology Panel 2008) and in the recently adopted 'Guidelines for objective demonstration and assessment of barriers' (CDM EB 2009).

A quick exploration of the data provided by the IGES CDM Project Database (IGES 2010), which includes information on what type of financial analysis is used in each CDM project, shows that of all the CDM projects already registered, or seeking registration, by the end of 2009, around 35% do not provide any financial data in their public documentation. The factors affecting the decision to include a financial analysis in the CDM project documentation are, as will be discussed in detail below, not only the technology involved in the project, but also the size of the project, the host country and notably the time passed since the CDM was initiated. This leads us to believe that the data do not suffer from selection bias.

It can be assumed that the technology involved in the project is the main determinant of the project's cost such that, if the cheap technologies never provide financial information, there will be selection bias. In CDM projects, the technology used is roughly determined by the "project type", which is a classification that includes both the economic sector involved (e.g. energy, agriculture, forestry, cement industry) and the generic technology used to reduce emissions (wind energy, hydro power, reforestation, energy efficiency improvements). In the IGES data, it can be seen that in terms of project types, only the projects reducing the industrial gas HFC-23 (a very potent GHG) never perform the financial analysis, which is because they are almost automatically considered additional, as they do not have any revenues other than the CERs. In all other project types (except in those that have only one or two projects registered), at least 30% of the projects provide some kind of financial data. Thus, for almost all project types there is some cost data available. This minimizes the risk of selection bias.

The size of the project is also an important variable affecting the decision to include a financial analysis in the documentation.[35] Almost 80% of the large CDM projects include a financial analysis, while only 45% of the small ones do. This is related both to the simplified modalities for additionality determination that exist for small projects, and to the above-mentioned regulatory mistrust against the barrier test. With respect to countries, in all main CDM hosts both projects with and without a financial analysis are found but there are considerable differences: in China, for example, over 90% of projects include some kind of financial data, while in Mexico and India only

[35] In the CDM, the size of the project is determined either in terms of its output capacity (for renewable energy projects), the amount of energy consumption reduced (for energy efficiency projects), or the amount of emission reductions achieved (for all other projects) (CDM Rulebook, 2010). Projects considered to be small according to these criteria can use simplified baseline and monitoring methodologies, which include, among others, a simplified demonstration of additionality.

71% and 45%, respectively, do so. Finally, the time elapsed since the first CDM project was submitted for validation (December 2003) increases the likelihood that a new project includes a financial analysis in its documentation, and this is applicable to most project types. Indeed, as the CDM rules have become clearer and stricter over time, more projects have chosen to perform an investment analysis to demonstrate additionality.

5.4.2 CDM-specific abatement cost calculation

As in Chapter 4, CDM projects' abatement costs were calculated, following Equation 4.1, as the net present value of the project costs (investment and operation) minus its revenues (e.g. income from electricity sales), all divided by the amount of GHG emission reductions it expects to achieve (indicated by the amount of emission reduction credits the project expects to generate over its crediting lifetime, also time-discounted).

Time discounting is critical in cost calculations. In capital budgeting, time discounting is used to reflect the interest rates the project is subject to, plus any financial risks applicable to either the country where the investment is taking place or the type of investment being made (Brealey and Myers 2000). In the CDM, discount rates are chosen by the project participant, but need to be justified. Still, as discussed in Chapter 4, there is a significant variation in the financial discount rates of projects in different technological categories and in different countries. Hence, the discount rates have been standardized for each country in order to have comparable information and to avoid the possible effect of discount rates being manipulated to obtain less attractive financial figures. The discount rate chosen for each country is the median of the discount rates utilized in the CDM projects within the sample taking place in the respective country, which was then rounded to the closest integer. As project developers have to substantiate the parameters they choose for the financial analysis, we consider the median to be a good indicator of the real discount rate applicable in the country. This is preferable to the mean because it avoids the influence of outliers, and to the mode because in several countries no mode was found and in most cases the median and the mode were identical. See Appendix 5A.1 for an overview of the standardized discount rates applied. See also Chapter 4 for further details on the methodology used for the cost calculations.

In this chapter, we use a larger sample of abatement cost data, covering a more detailed set of emission reduction technologies (project types) and a different range of host countries. Abatement cost information was extracted from 304 CDM projects, covering 36 emission reduction technologies.[36] These projects are mainly located in the eight host countries included in the sample (see below). For technologies where no sufficient financial information was found in these countries, the sample was extended to other countries. For the reason described above, HFC-23 reduction projects, which contribute a large percentage of the CERs generated in advanced developing countries, typically lack financial data in the project documentation; thus, abatement cost estimations

[36] 94% of the analysed projects are already registered under the CDM Executive Board of the UNFCCC. Projects at an earlier stage of the registration process were analysed only if no sufficient information was available from registered projects for a certain technology. In this case, care was taken that any requests for review were not related to the financial analysis of the project.

from secondary sources (Harnisch and Hendriks 2000; UNEP TEAP 2002; Jimenez 2005) were used.

The resulting abatement cost data were summarized in terms of the median abatement cost estimated for each technology (or CDM project type) included in the sample.

5.4.3 Expected size of CDM emission abatement

As an estimation of the amount of mitigation opportunities the CDM is expected to capture in a country, the annual amount of carbon credits that all the CDM projects currently proposed in the country estimate was aggregated. This information was taken from the CDM pipeline as of the end of December 2009 (UNEP Risoe Centre 2010). This is a rough estimation, as it does not include new projects that could be proposed in the future, but does include projects that have been proposed but not yet registered so far. Following project proposal rates at the time of analysis (91 projects/month)[37], about 1092 new projects are expected to enter the CDM pipeline by the end of 2010. Project registration rates (47 projects/month)[28] imply that only about 564 existing projects will be registered. As the CDM pipeline includes 2838 not-yet-registered projects as of the end of December 2009, the estimation is likely to be larger than the real size of the CDM by the end of 2010, because many projects in the pipeline will not yet start generating emission reduction credits (unless the registration process accelerates significantly in the following months, which is unlikely). Finally, this estimation does not take into account the fact that the emission reductions actually achieved are – for most project types – less than the estimations provided in the project documentation (Castro and Michaelowa 2008; UNEP Risoe Centre 2010). This all implies that, for our discussion of the low-hanging fruit argument, we are again on the safe side: if an overestimated CDM does not capture a large proportion of the theoretical abatement potential, then the low-hanging fruit issue is not likely to be a real problem.[38]

5.4.4 Comparison with theoretical abatement cost studies

From the cost and the size information, marginal abatement cost (MAC) curves for the CDM were built. In order to test the size hypothesis, these curves were compared with MAC curves showing the technical emissions abatement potential in the respective country. These theoretical MAC curves were built by merging the information from several studies that have performed bottom-up assessments of the technologies available for reducing GHG emissions in individual countries, their costs, and the amount of emission reductions that could potentially be achieved (the details of the studies used appear in Appendix 5A.2). Care was taken to avoid overlaps between the different studies. In order to test the cost hypothesis, a more detailed analysis of the portion of the abatement potential captured by the CDM for different cost categories was performed.

---

[37] Average over the last 3 months of 2009.

[38] It should be noted that performance in terms of actual generation of emission reductions differs between CDM project-types, with industrial gas projects clearly generating more reductions than initially projected, and methane reduction projects generating less. While taking this into account affects our estimation of CDM size for specific technological and cost categories (shown in Tables 5.2 and 5.3 below), it does not affect the main conclusion that the low-hanging fruit argument is weak. Calculations using issuance-corrected CER volumes are available on request.

5.4.5 Case selection

The low-hanging fruit argument is of interest to those developing countries under pressure to take more action to mitigate climate change. Action towards climate change mitigation is subject to the principle of 'common but differentiated responsibilities and respective capabilities' of countries (UNFCCC 2008c, p. 3), which means that countries with more responsibility for causing climate change and with better capabilities to take action should do more. Responsibility can be measured in terms of GHG emissions levels, in absolute terms or per capita. Capability can be measured in terms of GDP per capita, which is an indication of the economic wealth of the country. Further, the low-hanging fruit problem is potentially relevant only to those countries in which the CDM has become significant.

Thus, from the countries that are hosting at least 10 registered CDM projects, those that ranked highest, in terms of absolute CO_2 emissions, CO_2 emissions per capita and GDP per capita, were taken by building an index that incorporates these three indicators with equal weights. Data was obtained from IEA (2007b) and IMF (2008). The resulting sample includes China, South Korea, Mexico, South Africa, Thailand, Argentina, Malaysia and Israel. For Malaysia and Israel it was not possible to collect sufficient information for building theoretical abatement cost curves, hence they are discarded from the analysis.[39] However, they have been used for extracting CDM project cost information. India and Brazil, two important CDM host countries, are not covered in the sample: India has very low levels of emissions per capita and GDP per capita; Brazil has very low levels of emissions per capita and its emissions come mainly from the land use sector, which is currently not covered under the CDM. Chile had an index value very similar to the one of Argentina. As Argentina has higher absolute emissions, this country was preferred for the analysis.

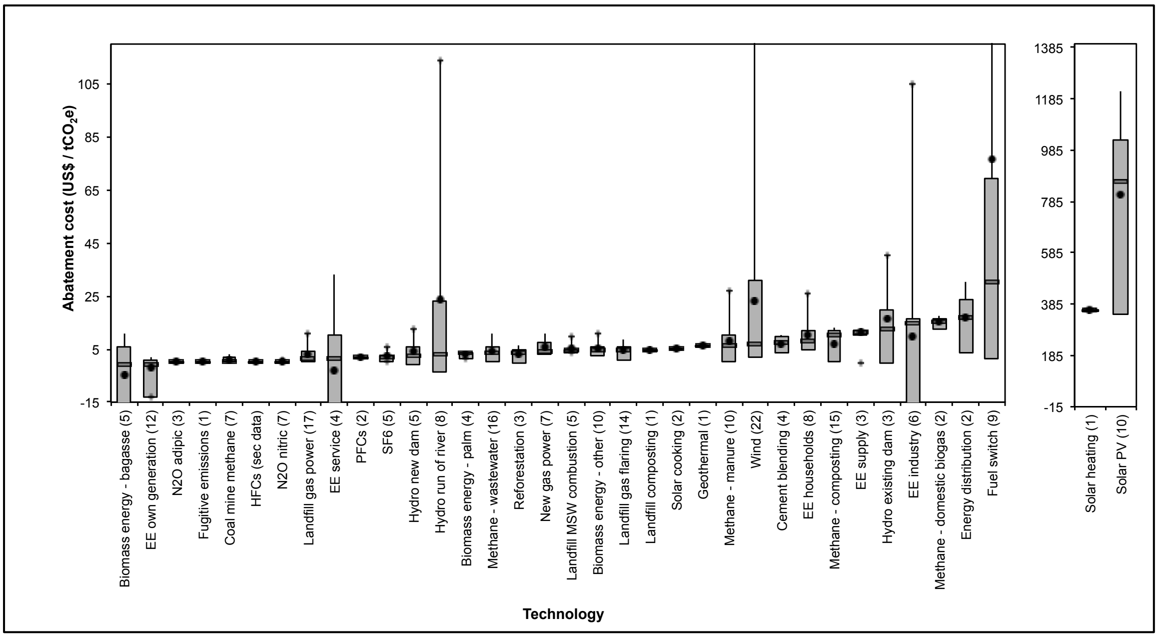
5.5 Results

5.5.1 CDM abatement costs

Figure 5.1 shows box plots of the estimated emissions abatement costs of the projects in the sample, after standardizing their financial discount rates. This graph is very similar to the one shown in Figure 4.2, but relies on a larger dataset of projects and host countries. Again, the results are consistent with cost curves reported in other studies, in that reducing emissions of methane and industrial gas reduction projects appears generally cheaper than reducing emissions of CO_2. Again, despite high variability in some project types, most projects seem to be financially viable at primary (on average US$ 13 for 2009) or secondary (about US$ 20) carbon prices.

[39] The consultancy McKinsey has prepared a MAC curve for Israel, but the full report is only available in Hebrew, and the executive summary in English does not provide sufficient information for our purposes. Further, it focuses on the year 2030, which is too far away in the future to compare with the CDM now.

Figure 5.1: Estimated abatement costs of CDM projects (US$/$tCO_2e$), by technology



Sources: CDM projects' Project Design Documents, own calculations. For HFC projects: Harnisch and Hendricks (2000); UNEP TEAP (2002); Jimenez (2005). The figures in parentheses show the sample size for each technology.

5.5.2 CDM abatement cost curves

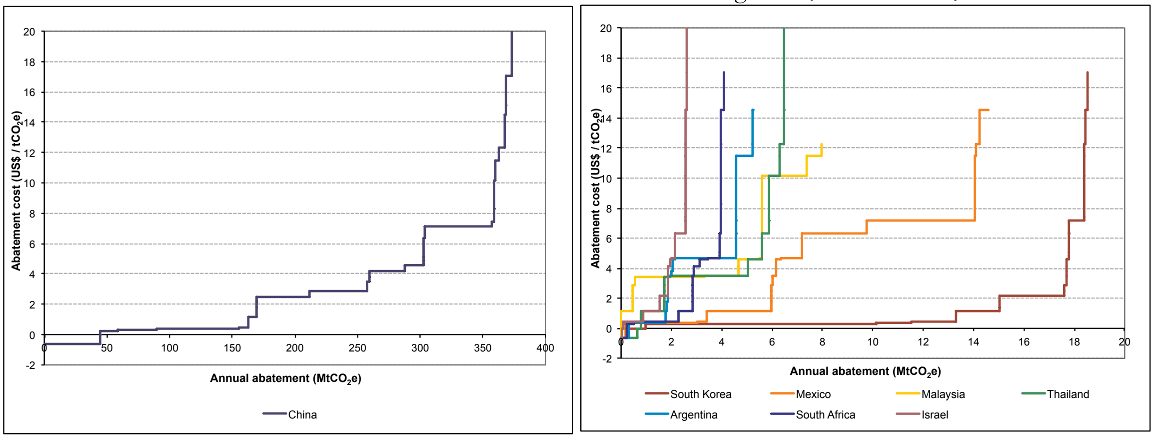
Figure 5.2 (a) and (b) shows the estimated GHG abatement cost curves for the CDM of China and the other countries. As explained, these curves were built by taking the median abatement cost of each technology (shown in Figure 5.1) and the amount of emission reductions expected to be achieved annually by all CDM projects in the pipeline as of December 2009 in the respective countries, also classified by technologies.

In these curves again, there are some project types without cost information. These appear at the left end of the curves, as having zero abatement costs. The projects without cost information represent 5.2% of the CDM abatement potential in South Korea, 2.2% in Thailand, 0.7% in Israel, 0.1% in China and 0% in Argentina, Malaysia, Mexico and South Africa. While this inclusion enlarges the quantity of low-cost (or zero-cost) project options, these data were not omitted from the curves as they allowed for a more realistic picture of the overall abatement potential. This enables us again to be on the cautious side of the estimations.

Figure 5.2: GHG abatement cost curve for the CDM pipeline

(a): China

(b): South Korea, Mexico, Malaysia, Thailand, Argentina, South Africa, Israel



Sources: Cost data from PDDs, potentials from UNEP Risoe Centre (2010), own calculations.

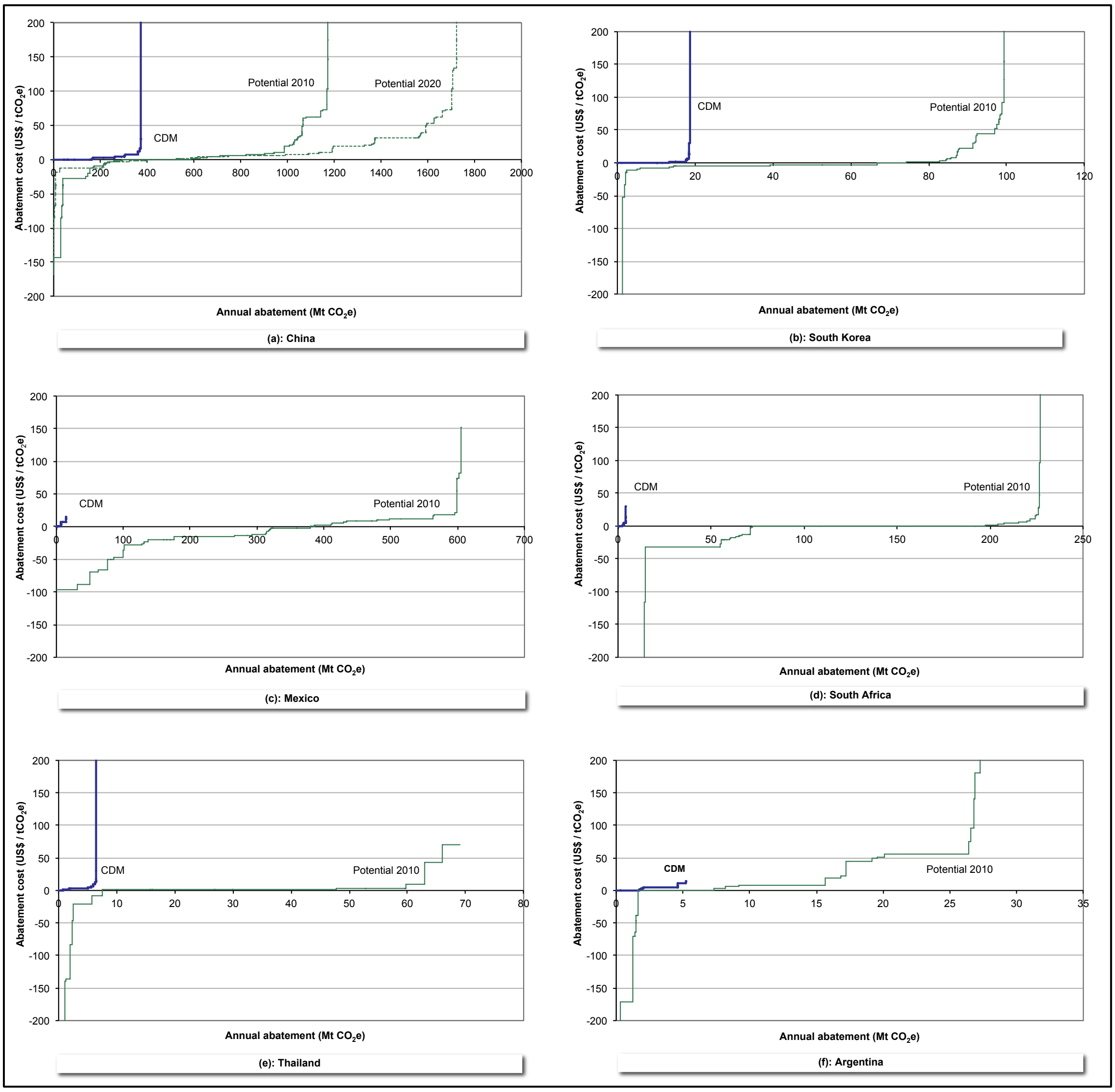
5.5.3 Comparison with theoretical abatement curves: size

Based on data reported in 18 climate mitigation studies in the countries included in the sample (see Appendix 5A.2), theoretical GHG abatement cost curves were built, trying to cover as many emission reduction options from as many economic sectors as possible, and including CO_2, methane and, when information was available, industrial gas emissions. In all countries, the curves were built to reflect the emissions reduction potential in the year 2010, which should be comparable to the current CDM in which a static stock of mitigation options is assumed. In the Chinese case, an abatement curve for the year 2020 has also been included, to provide an idea of how the emissions reduction potential is expected to grow in the future.

The indicator of the size component of the low-hanging fruit argument is provided by the horizontal difference between the CDM-specific and the theoretical abatement cost curves in each country. This is shown in Figure 5.3 (a)-(f). Table 5.1 presents a summary of calculations regarding how much of the theoretical abatement potential in each country is being captured by the CDM, by dividing in each case the total abatement expected from the CDM by the total theoretical abatement potential.

Figure 5.3 and Table 5.1 show that, in all cases, the CDM is capturing only a portion of the estimated emissions reduction potential in the respective countries. In China this portion is around 32%, thus it could be said that there is a risk that the CDM is exhausting the stock of emission reduction possibilities in the country. However, as time passes, new mitigation opportunities arise, so that the current CDM represents only about 22% of the Chinese emission reduction potential in 2020. In South Korea and Argentina, the CDM has captured less than 20% of the potential identified up to 2010, and in Mexico, South Africa and Thailand this portion is below 10%. Thus, we see that in most countries, the risk of a "low-hanging fruit issue" is, at least in terms of the current size of the CDM, weak.

Figure 5.3: Comparison between expected CDM abatement and potential abatement



Note: The potential abatement curves are built on the basis of data from the studies listed in Appendix 5A.2. They do not include emission reduction opportunities that were uncovered by the CDM and had not been previously forecast in the mentioned studies.

Looking in more detail at which technologies have been taken up by the CDM, Table 5.2 shows the portion of the theoretical potential that is being captured by each technological category. The table shows that, in some sectors, such as agriculture and energy efficiency, very little of the identified potential has accessed the CDM. In other sectors, on the contrary, much larger emission reductions are being realized through the CDM than those identified in the theoretical studies, mainly in energy generation from renewable or other sources, or in reduction of industrial gases.

While it appears that the CDM concentrates in specific technological niches, it is clear that the theoretical abatement studies did not uncover all the existing potential. The projections have been too conservative, especially in energy generation, where many countries have experienced an unprecedented growth (for example the explosion of wind power capacity in China since 2006, which was not foreseen by the analysts) and where the potential for renewables is difficult to estimate. Again, because of this, the conclusions that are drawn remain on the cautious side of whether the CDM is exhausting the mitigation potential.

Table 5.1: Emissions abatement potential captured by the CDM

Country	Percentage of abatement potential captured by CDM	
China	31.9%	of 2010 potential
	21.7%	of 2020 potential
South Korea	18.4%	of 2010 potential
Mexico	2.4%	of 2010 potential
South Africa	1.9%	of 2010 potential
Thailand	9.4%	of 2010 potential
Argentina	17.7%	of 2010 potential

Note: Percentages based on the incomplete theoretical abatement potential (without including emission reduction opportunities that were uncovered by the CDM and had not been previously forecast).

Table 5.2: Emissions abatement potential captured by the CDM, by technologies

Technological category	Percentage of abatement potential captured by CDM					
	China	South Korea	Mexico	South Africa	Thailand	Argentina
Agriculture	0.0%	0.0%	0.0%	-	-	-
Coal mine methane	15.9%	-	25.7%	0.0%	-	-
Energy efficiency in households / buildings	0.1%	0.0%	0.0%	0.0%	0.0%	-
Energy efficiency in industry	0.3%	0.2%	3.4%	0.3%	0.0%	2.2%
Energy efficiency in own generation	19.0%	0.0%	0.4%	infinite	20.2%	75.4%
Thermal power	27.7%	0.0%	0.1%	2.9%	0.0%	-
Forestry	0.4%	0.0%	0.0%	0.0%	0.0%	2.2%
Fugitive emissions	3.2%	0.0%	2.2%	infinite	-	-
Industrial gases	73.5%	218.6%	171.9%	infinite	infinite	infinite
Renewable energy	678.2%	infinite	4.4%	4.5%	infinite	0.9%
Other energy	880.7%	6.6%	0.0%	0.1%	0.0%	35.0%
Waste	7.6%	9.4%	38.1%	64.4%	infinite	48.5%
Transport	Infinite	0.0%	0.0%	0.0%	0.0%	0.0%

Note: Percentages based on the incomplete theoretical abatement potential (without including emission reduction opportunities that were uncovered by the CDM and had not been previously forecast). 'Infinite' denotes a category, for which the theoretical abatement studies did not identify any emission reduction potential, but the CDM did nonetheless. '-' denotes a category where no emission reduction opportunities were identified, neither in the CDM, nor in the theoretical studies.

Figure 5.3, Table 5.1 and Table 5.2 compare the CDM to theoretical abatement curves that were built on the basis of literature research, but resulted in some mismatch because the CDM uncovered significant emission reduction possibilities that had not been identified by the previous theoretical abatement potential studies. A more correct comparison would thus be between the CDM and a completed theoretical abatement that includes both the forecasts from the literature and the extra abatement (beyond the forecasts) achieved by the CDM. Such a comparison would imply that the CDM has captured even a smaller portion of the abatement potential than estimated in Table 5.1 and Table 5.2, strengthening our conclusions.

Figure 5.4: China: Comparing actual CDM, potential CDM, theoretical potential and completed theoretical potential

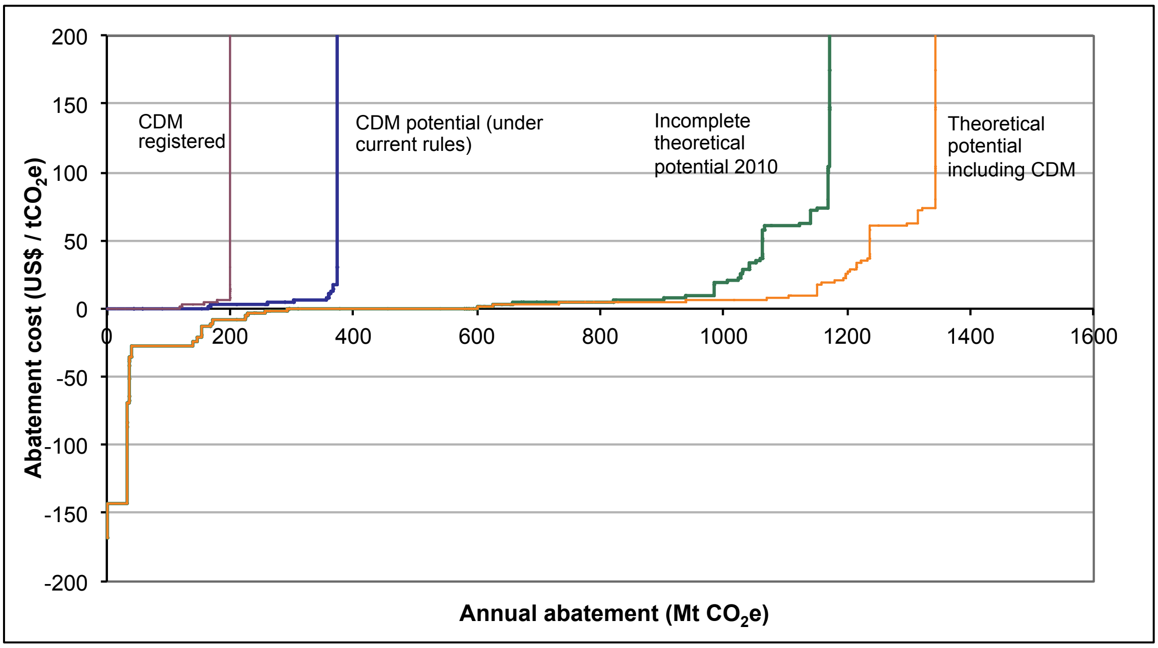


Figure 5.4 illustrates this situation for the case of China. Four abatement cost curves were compared: that of the CDM projects registered up to December 2009, which represents the lower range of annual abatement that will be achieved by the CDM; that of all CDM projects in the pipeline by December 2009, representing the higher range of abatement that will be achieved by the CDM under current rules up to 2012 (this is the same curve as in Figure 5.3); that of the incomplete theoretical abatement potential by the year 2010, gathered from the literature (same curve as in Figure 5.3); and that of a completed theoretical abatement potential that results from adding the extra abatement opportunities uncovered by the CDM to the previous curve. If this last curve is taken as being the real theoretical abatement potential in China, the CDM would capture 28% of the theoretical

potential under the high-range CDM abatement scenario, which shows again that the results presented above are conservative in terms of the relevance of the low-hanging fruit problem.

5.5.4 Comparison with theoretical abatement curves: costs

In all countries analysed, the cost range of the CDM projects (vertical axis in the abatement cost curves) covered only a fraction of the theoretical abatement cost range. This is explored in more detail in Table 5.3. In China, South Korea and Thailand, it is observed that the CDM captures some very costly emission reduction options. These are solar energy projects, subsidized in the latter two countries through feed-in tariffs. In China and South Africa some CDM projects reach abatement costs of nearly US$ 50-70, which is also above the market price for emission reductions. In Mexico and Argentina, finally, the CDM mainly stays below the US$ 13 threshold, so that the CER primary price makes most projects attractive. From this analysis, it can be concluded that in Mexico and Argentina the CDM seems to be focusing almost exclusively on the cheaper projects, while in the other countries there is also some (albeit marginal) exploration of higher cost emission reduction opportunities.

Table 5.3: Emissions abatement potential captured by the CDM, by cost categories

Cost category	Percentage of abatement potential captured by CDM					
	China	South Korea	Mexico	South Africa	Thailand	Argentina
< 0 US$/t$CO_2$e	3.0%	0.1%	0.1%	0.4%	8.6%	18.9%
0 - 10 US$/t$CO_2$e	27.9%	82.6%	11.0%	2.5%	10.2%	30.2%
10 - 20 US$/t$CO_2$e	148.5%	288.7%	0.2%	0.3%	infinite	55.8%
20 - 30 US$/t$CO_2$e	89.4%	0.0%	137.8%	0.0%	-	3.7%
30 - 40 US$/t$CO_2$e	126.9%	2.6%	-	-	-	-
40 - 50 US$/t$CO_2$e	0.0%	0.0%	-	0.0%	0.0%	0.7%
50 - 60 US$/t$CO_2$e	2392.1%	0.0%	0.0%	-	-	0.2%
60 - 70 US$/t$CO_2$e	0.2%	65.8%	-	infinite	0.0%	-
70 - 80 US$/t$CO_2$e	0.2%	0.0%	0.0%	-	-	0.0%
> 80 US$/t$CO_2$e	2.7%	13.8%	0.0%	0.0%	infinite	0.9%

Note: Percentages based on the incomplete theoretical abatement potential (without including emission reduction opportunities that were uncovered by the CDM and had not been previously forecast). 'Infinite' denotes a category, for which the theoretical abatement studies did not identify any emission reduction potential, but the CDM did nonetheless. '-' denotes a category where no emission reduction opportunities were identified, neither in the CDM, nor in the theoretical studies. Cost categories were defined by matching technologies used in the CDM with technologies included in the theoretical studies, and taking the abatement costs estimated in the theoretical studies. For technologies appearing in the CDM and not in the theoretical studies, our estimation of abatement costs was taken.

In several theoretical GHG abatement cost studies consulted (ADB 1998a; ADB 1998b; UNDP and GEF 1999; World Bank 2002; US EPA 2006; Bakker et al. 2007; Enkvist et al. 2007; Wetzelaer et al. 2007; Johnson et al. 2010), the estimated potential of GHG reduction options with net negative costs is significant. Such "no-regret" reduction options seem to conflict with rational behaviour: if an investment entails negative costs, it is financially profitable, and this business opportunity should have been captured. The reasons for the existence of this negative-cost potential are market imperfections leading to lack of knowledge about the reduction options, misaligned incentives of companies and consumers, social preferences, lack of priority, insufficient capital availability and differing definitions of cost (e.g. social versus financial cost). The least-cost abatement measures – especially demand-side energy efficiency measures – imply mobilizing billions of diffuse emission sources across many sectors and regions, and thus achieving them may be politically challenging. It is often suggested that in order to remove these market barriers, high transaction costs are incurred, which are normally not included in abatement cost studies.

The CDM imposes further costs to these abatement options, especially to small-scale ones: monitoring methodologies need to be designed and approved; project design, validation, registration and verification of emission reductions need to be paid for; monitoring plans and equipment need to be put in place. It is thus not too surprising that the large reduction potential from energy efficiency and transport, typically with abatement costs below zero, is not being taken up by the CDM.

The observation that many theoretically cheap abatement options remain on the table in developing countries reflects the limitations of the CDM for overcoming non-market barriers to these abatement options. From this point of view, it is argued that the CDM has grasped the cheap abatement options that have been easy to obtain, while mostly leaving alone the abatement options that are more difficult to implement in practice.

5.6 Conclusions and limitations of the chapter

An attempt to use empirical data to test the low-hanging fruit hypothesis regarding the CDM – the claim that it is using up the cheaper emission reduction options in its host countries, thereby leaving them without future opportunities for cost-effective emission reductions when they adopt climate change mitigation commitments – was presented. By comparing the portion of the emissions reduction potential in six countries captured so far by the CDM with the potential available according to several studies, it is concluded that the low-hanging fruit argument is weak.

It was found that the CDM is not yet taking up a large portion of the identified theoretical abatement potential in most of the countries assessed, with the exception of China where it reaches about 32%. In terms of costs, while most of the emissions reduction opportunities grasped by the CDM are below the average market price, there is still plenty of low-cost opportunities to be harvested. Finally, while Mexico and Argentina appear to use the CDM almost exclusively for harvesting the low-hanging fruit, more expensive projects are accessing it in the other countries analysed (China, South Korea, Thailand and South Africa). A more detailed study of why these more expensive projects are being captured could shed further light on how to direct the CDM for both promoting technologies that are usually difficult to access and encouraging learning effects, thereby creating new "low-hanging fruits". Further, recognition of the transaction costs and non-market barriers involved in the implementation of many theoretically cheap abatement options may explain why many of these options are still left untouched.

Even with these results, if the CDM (or a similar offsetting mechanism) is expanded significantly, there is a risk that cheap abatement options may become scarce in the countries involved. Programmatic CDM, which is only just taking off, can open the door for projects in rarely covered sectors (e.g. households and small-scale renewables). Potential changes in the rules of the CDM, allowing for the inclusion of carbon capture and storage (CCS); nuclear energy; avoided deforestation; other land use, land use change and forestry (LULUCF) projects; and the abatement of GHGs currently not covered by the Kyoto Protocol, could also lead in this direction. The market mechanisms currently under discussion in the negotiations– sectoral crediting, or credited NAMAs (Nationally Appropriate Mitigation Actions) – could also expand offsetting significantly. While these new approaches will only materialize if new demand for emission reduction credits from countries with emission reduction targets is created, careful design is needed to keep positive incentives for mitigation in developing countries.

Finally, a note on the limitations of this chapter. While data on emission reduction costs and potentials was collected from as many sources as possible, the theoretical potential identified is quite conservative, as illustrated by the many emission reduction options that the CDM has captured without first being identified in the theoretical studies. This implies both that the MAC curves presented here are to be used with care, and that our result – that the CDM is not yet capturing a large portion of this potential – is robust. Further, cost data from CDM projects is likely to be biased downwards for costly technologies and upwards for cheap technologies. The reason for this bias is that CDM projects need to demonstrate that they are financially unattractive without the CDM revenues, but the input of CDM revenues make them attractive. The few, very expensive, projects found in the CDM acknowledged that they were not financially feasible, but were intended for demonstration purposes. Finally, even if this possible bias is disregarded, CDM cost information was mainly gathered from the six countries the study focuses on. This renders the project sample by technologies or project types quite small in some cases. Thus, it is likely that geographical and technological differences lead to more variability in terms of abatement costs within project types than is reflected here. Further effort in collecting data from more countries could lead to more detailed technological categories with more accurate cost data.

Appendix 5A.1: Standardization of discount rates

Country	Standardized discount rate
Argentina	11%
Brazil	15%
China	8%
Ecuador	12%
India	11%
Indonesia	17%
Israel	10%
Jordan	8%
Kenya	15%
Malaysia	10%
Mexico	12%
Moldova	10%
Morocco	10%
Mozambique	13%
Peru	12%
Philippines	12%
Qatar	10%
Rwanda	12%
South Africa	12%
South Korea	7%
Thailand	10%
United Arab Emirates	8%

Appendix 5A.2: Sources of data for theoretical MAC curves

Country	Data sources
Argentina	NSS Program (1999) UNDP and GEF (1999)
China	Yamaguchi (2003) Yamaguchi (2005) US EPA (2006) Wetzelaer et al. (2007) Cai et al. (2008)
Mexico	Sheinbaum and Masera (2000) US EPA (2006) Bocanegra (2009) Johnson et al. (2010)
South Africa	World Bank (2002) Winkler et al. (2008)
South Korea	ADB (1998a) Roh (2005) Roh (2006) Roh and Kang (2004) US EPA (2006)
Thailand	ADB (1998b) Shrestha and Bhattacharya (2002)

6. DO DOMESTIC RENEWABLE ENERGY PROMOTION POLICIES LEAD TO MORE CLEAN DEVELOPMENT MECHANISM PROJECTS?

6.1 Introduction

In Chapter 5, the CDM portfolio of eight countries was analysed in terms of the size and abatement cost of the emission reduction options that have been captured. It was found that, while the CDM mostly focuses on cheap emission reduction options so far, these have not yet been exhausted in its main host countries. The empirical findings support the hypothesis that the CDM's reliance on the market makes it focus on the mitigation options that are cheaper – and easier to realize – first.[40] This is efficient from the economic point of view and is actually the intended role of the CDM: the mechanism was designed as a cost-containment instrument that would provide industrialized countries with emission targets the opportunity to seek cheaper emission reduction options abroad and count them as their own (Werksman 1998; Toman et al. 1999).

Nevertheless, this is not exactly what we observe. While most of the mitigation achieved by the CDM so far is clearly low-cost in nature, the analysis in the previous chapter clearly showed that there are some high-cost abatement options that have been proposed (and registered) as CDM projects. Specifically, expensive renewable energy (RE) projects, such as photovoltaic plants, are – albeit still in small numbers – in the CDM portfolio. One possible explanation for this observation is that the CDM is not the only source of financial incentives for these projects, so that other financial incentives are acting as a complement to the CDM subsidy. In this chapter, I argue that, while the CDM by itself is likely not sufficient to spur investment in high-cost renewable energy power plants in developing countries at current carbon credit prices, domestic RE support policies can be complementary to the CDM incentive, resulting in more RE investment within the carbon market being observed.

---

[40] Cheap abatement options may not be equal to easy abatement options. Marginal Abatement Cost (MAC) curves usually show a large available potential of negative-cost emission reduction options that have not been realized yet (see e.g. Enkvist et al. 2007 or Wetzelaer et al. 2007). However, these curves usually incorporate only engineering and operational costs of abatement, disregarding potential information, financial and other transaction costs, as well as other non-market barriers (such as technological risks) and market imperfections that may prevent the adoption of these measures. Lütken and Michaelowa (2008) criticize the MAC approach of modelling emission reduction priorities, and posit that corporate decision-making (i.e. relevance towards core business, geographical or market priority, and risk perceptions) and microeconomic considerations are more relevant to CDM investment than macroeconomic abatement cost estimations. Moreover, the CDM process incorporates additional transaction costs that are higher for small projects, such as the theoretically cheap disaggregated energy efficiency measures (Michaelowa and Jotzo 2005). This all leads to the empirical observation that cheap options are not always realized.

I test this hypothesis empirically by analysing econometrically the effect of domestic RE support policies on the amount of RE CDM investment in developing countries, controlling for all those country characteristics that may more generally affect RE investment and CDM participation, and applying panel two-part and Heckman selection models. To control for the potential endogeneity of the support policies, instrumental variables estimation is also applied.

In the next section, I discuss the current status of the adoption of RE support policies in developing countries, and of its interaction with the CDM. Section 6.3 details the theoretical framework for the study, and the resulting hypotheses. In section 6.4 I describe the data and operationalization, before explaining the empirical estimation procedures and discussing the results in section 6.5. In section 6.6, finally, the conclusions are presented.

6.2 Current status of RE in developing countries

The world is currently witnessing an accelerated development in the field of renewable energy. Nonetheless, the growth in renewables is just keeping pace with the rising needs for energy and is not yet resulting in a visible turn away from fossil fuels at the global scale (IEA 2010b). Renewable energy now accounts for about 19% of final energy consumption (REN21 2010), but most of this supply is still provided by traditional biomass used for cooking or heating in developing countries (13%) or by large-scale hydroelectric power (3.2%). Still, some of the modern renewable energy sources – small-scale hydro, wind, solar, geothermal, tidal and biofuels – are growing very fast. For example, for the past 5 years, solar photovoltaic and wind electricity capacity have grown at an average annual rate of 60% and 27%, respectively. These trends are being witnessed both in industrialized OECD countries and in some emerging economies.

Fundamental economic and political developments accompany these trends. Rapidly increasing energy needs in developing and emerging economies, coupled with rising costs of fossil fuels and energy security concerns are some of them (US EIA 2009). At the same time, R+D investments and the accelerated market growth of renewables are leading to technological improvements, economies of scale, learning effects and cost reductions (Junginger 2005; Junginger et al. 2005; Nemet 2006; Jamasb and Köhler 2008). Finally, climate change concerns are leading some governments and stakeholders to promote an increased reliance on non-fossil energy sources (Goldemberg 2006).

These developments are supported by changes in the political arena. The fierce competition for market power in the renewables sector is leading governments to invest in research and development (R+D) and other technology-push policies. Indicative or mandatory renewable energy targets, coupled with financial incentives that set the price, lower the cost or provide capital for renewable energy are increasingly used to support market development (REN21 2010). Internationally, emission targets for industrialized countries and the Clean Development Mechanism in developing countries seek to tackle climate change mitigation. As one of the main contributors to greenhouse gas emissions, the energy sector is also responding to these international incentives. In the following paragraphs, we describe the main existing international and domestic policy instruments related to renewable energy deployment in developing countries, which are the focus of analysis of this article.

6.2.1 Renewable energy in the Clean Development Mechanism

As of December 2011, 5661 projects involving the use of renewable energy technologies have been proposed under the Clean Development Mechanism.[41] If successfully registered and implemented, they would reduce about 570 million tCO_2e per year and result in the installation of 207 GW of electricity capacity. This represents about 75% of the CDM portfolio in terms of projects, and 56% in terms of annual emission reductions (UNEP Risoe Centre 2012).

The power capacity that would be added by these CDM projects represents about 15% of the global renewable power capacity (1360 GW) (REN21 2012). The contribution of the RE CDM projects to RE capacity is thus significant. How much of this expected capacity addition can be attributed solely to the CDM is however a difficult question to answer. CDM-related revenues are relatively small: a carbon price of 17 US$/$tCO_2e$ implies a subsidy of 1.0 to 31.9 US$/MWh of electricity produced, depending on the carbon intensity of the underlying electricity grid.[42] With typical generation costs at 50-90 US$/MWh for wind, 50-120 US$/MWh for biomass and 150-300 US$/MWh for utility-scale photovoltaic energy (REN21 2010), and retail electricity prices between 22 and 207 US$/MWh including taxes in various developing countries (US EIA 2011), the CDM margin is not always sufficient to secure profitability. Domestic-level incentives are thus needed to make up for the remaining difference between profits and costs.

6.2.2 Domestic RE support policies

There are many types of domestic policies that can generate positive incentives for RE deployment by addressing different types of barriers. R+D and other technology-push policies are undoubtedly important for fostering innovations and long-term cost reductions in renewable energy. Broader electricity-sector restructuring policies may also affect RE deployment, depending on their design (Kozloff 1998; Martinot 2002). For example, Martinot et al. (2002) and Martinot (2002) argue that a liberalized energy system allowing the participation of private actors in electricity generation may already encourage a diversification of electricity production towards renewable sources, but that more specific promotion policies are also needed nonetheless.

However, the focus of this chapter is on policies that are intended to directly influence the deployment of RE technologies for power generation. These are policies that set a target for RE capacity (e.g. renewable portfolio standards or renewable energy targets), that set preferential prices for RE sales (feed-in tariffs, competitive bids), or that reduce the costs (or other barriers) of RE

---

[41] Counting projects registered, in the process of registration and under validation, and excluding those already rejected or withdrawn.

[42] This calculation was made on the basis of the average secondary CER price over the period 2004-2009 (US$ 17.04), obtained from the GTZ CDM Highlights (http://www.gtz.de/de/themen/umwelt-infrastruktur/umweltpolitik/18324.htm); as well as the lowest (0.06 tCO_2e/MWh) and the highest (1.874 tCO_2e/MWh) grid emissions factor listed by the IGES grid emissions factors database (IGES 2011).

generation (capital subsidies, investment and production tax credits, public loans) (Beck and Martinot 2004; REN21 2008; REN21 2010).

Several reasons explain this focus. While R+D incentives undoubtedly contribute to cost reductions and thus increased RE investment, these effects take place in the medium to long term. Furthermore, investments in R+D may not just influence the domestic market, because technologies can be exported and used in other countries as well. So, it is difficult to argue for a direct, short term effect of R+D incentives in a country on CDM investments in the same country. With respect to broader energy policies, such as the reform and liberalization of energy markets, they can both encourage and discourage the deployment of new RE technologies, as discussed by Martinot (2002). Thus, we do not have a clear theoretical argument on their potential effects on CDM-related RE deployment. Data on electricity sector reform in developing countries is incomplete and available only for the year 1999 (ESMAP (Energy Sector Management Assistance Programme) 1999), so that it is unsuitable for our analysis. However, it is likely that these broader policies are correlated with the more direct RE support measures we are considering, because both sets of measures may come in one legislation package, so that our variable for the RE support measures may already be capturing some of the effect of electricity sector reform. In contrast, the market-push policies described above are expected to have a direct and relatively short-term impact on RE investment at the domestic level, and information on their implementation in developing countries is being reported regularly.

69 developing countries have been identified by the latest REN21 report (2012) as having a renewable energy target, and about the same amount of them have some sort of policy to incentivize renewable power generation financially. Among developing countries, the most common incentive is the reduction of sales, energy, excise, or value added tax, but other frequent policies are feed-in tariffs, investment or other tax credits, and the provision of public investment, loans or financing (see Table 6.1).

Table 6.1: Amount of non-Annex I countries that have enacted renewable energy support policies, 2011

Type of policy	Number of non-Annex I countries
Feed-in tariff	36
Renewable Portfolio Standard/quota	10
Capital subsidies, grants or rebates	27
Investment or other tax credits	19
Sales tax, energy tax, excise tax, or VAT reduction	47
Tradable RE certificates	3
Energy production payments or tax credits	7
Net metering	15
Public investment, loans, or financing	31
Public competitive bidding	23

Source: REN21 (2012)

For RE support policies to be successful, they need to be carefully designed to tackle the real barriers that prevent RE deployment in each situation, and to avoid undesired effects. Rajsekhar et al. (1999) and Martinot et al. (2002) show, for example, that investment-based (instead of generation-based) incentives for wind power in India led to large investments with low operating performance, and sometimes not operating at all. In some cases, even if promotion policies are in place, they do not suffice to overcome some crucial barriers to RE development. An important example is the accessibility to the grid: due to its intermittent character, renewable power frequently faces higher grid connection costs than conventional thermal electricity, or even unwillingness of utilities to provide grid access (Rajsekhar et al. 1999). Promotion policies sometimes have negative effects, too. It has been discussed, for example, that the high German feed-in tariffs, and the Indian investment depreciation incentives for wind energy may have resulted in inflated turbine prices, because the subsidization of energy production reduced the incentives to save in investment costs (Rajsekhar et al. 1999; Junginger et al. 2005). In other cases, changes in pricing policies or tax incentives can stop investments, as experienced in Tamil Nadu with wind power tariffs in 2001 and in Sri Lanka with small hydro power in 1999 (Jagadeesh 2000; Martinot et al. 2002). Benecke (2009) goes further and posits that not only policy design, but also implementation practices, political will, institutional effectiveness, and, more importantly, stakeholder attributes and interrelations – in the form of networks – determine effective renewable energy governance in non-OECD countries. Although we are aware of these challenges, this article will assume that RE promotion policies do fulfil their goals. In addition, by looking at RE capacity deployment and not at power generation, the analysis avoids some of the generation-related barriers described in this paragraph.

Rising trends both in the enactment of RE support policies and in the use of renewable electricity sources in developing countries are evident, as well as in the diffusion of the CDM as an international mechanism that provides additional funding for, e.g. RE projects. The fact that many RE support policies provide a financial incentive that can be added to the CDM's financial incentive to make RE more attractive speaks for such a positive effect of policies on CDM project development. Regulatory hurdles may however prevent such effect. The CDM relies on the assumption that the emission reduction projects it finances are additional to any reductions that would have taken place on a business-as-usual scenario. For example, emission reduction credits may be granted to projects envisaging the distribution of energy-saving lamps in places where they are not commonly used. If, however, the use of such lamps is mandatory by law, then distributing them would not be additional. While this concept of additionality seeks to ensure that the emission reductions achieved through the CDM are real, it may have the perverse incentive of preventing governments from enacting policies that support emission reduction activities in order not to risk CDM-related revenues. In response to this trade-off, the CDM Executive Board (EB) established at its 16th meeting that policies or regulations that provide a positive comparative advantage to less emissions-intensive technologies, enacted after 2001, would not need to be taken into account when establishing CDM project baselines (CDM EB 2004). Since this was clarified, RE CDM projects have been allowed to profit from incentives provided by new RE support policies.

New controversy arose during 2009, when the CDM EB put under review and rejected several Chinese wind projects, after it noticed that power tariffs paid to these projects were decreasing, making it fear either that China was decreasing the tariffs to make the projects look less financially attractive and thus more "additional", or that the CDM was being used to replace government subsidies (He and Morse 2010). After discussions on the way forward, the EB has now decided that, excluding some exceptions, project proponents should use, for their additionality determination, the highest tariff that a project has ever received in the same region (CDM EB 2011). Thus, the fundamental paradox between additionality concerns and broader incentives for developing countries still subsists: while including domestic promotion policies in the baseline for additionality creates perverse incentives by discouraging those policies, not including them generates the risk that business-as-usual projects will be credited (He and Morse 2010).

Not only may the CDM rules constrain projects that have been supported through national RE promotion policies from accessing the carbon market, as in the Chinese case, but also the way these policies have been designed may have a similar effect. An example is the case of the Brazilian PROINFA (Programa de Incentivo às Fontes Alternativas de Energia Elétrica) programme, which was launched in 2002 with the goal to promote RE deployment by providing guaranteed tariffs. In 2006 the Brazilian Government decided that all CERs earned by independent power producers participating in the PROINFA programme would belong to Electrobras, the state utility that manages PROINFA. This effectively discouraged private investors from accessing the PROINFA programme, especially after regular tariffs rose above the price guaranteed by PROINFA and the CDM subsidy became comparatively more attractive (Friberg and Castro 2009).

The Chinese and the Brazilian examples described above show cases in which the CDM and domestic policies can act as substitutes of each other, rather than complements as it was hypothesized earlier in this chapter. However, this evidence is still case-specific and limited. This chapter thus attempts to assess the effect of domestic RE policies on renewable energy CDM projects by looking at all developing countries participating in the CDM empirically.

6.3 CDM-related RE investments and RE promotion policies: possible determinants

In order to assess the effect of RE promotion policies on CDM RE investment, we need to control for all other factors that may be influencing such investments as well. Additionally, as enacting RE promotion policies may be endogenous to investment in CDM projects, we need to find suitable instruments for our main explanatory variable. In this section we outline the theoretical background that supports our choice of control and instrumental variables later on.

Firstly, we look at studies that assess the conditions generally leading to investment in renewable energy, with focus on grid-connected electricity. They show us the factors that may affect RE investment in addition to the effect of RE promotion policies or of the CDM. Secondly, we utilize the more recent literature on the barriers for CDM investment and the geographical distribution of

CDM projects to find the factors that facilitate CDM investment, which we will also need to control for.[43] Finally, we use the literature on the factors leading to the adoption of environmentally-friendly policies to find possible explanations for the increased adoption of RE promotion policies in developing countries. This will enable us to find suitable instruments for RE promotion policies.

Factors leading to investment in renewable energies

We are not aware of any cross-country study that systematically analyses the factors leading to investment in renewable energies, especially in developing countries. Some case studies have looked at the effectiveness of specific RE promotion policies in individual European countries and US states (Gouchoe et al. 2002), and there are a few qualitative comparative analyses of renewable energy deployment in the same countries (Bird et al. 2005; Mitchell et al. 2006; Gan et al. 2007). Menz and Vachon (2006) and Carley (2009) assessed econometrically the effectiveness of Renewable Portfolio Standards in promoting the deployment of renewable energy in US states; Marques et al. (2010) look at general drivers of RE deployment in European countries. Benecke (2009) and Jagadeesh (2000) evaluated the conditions leading to wind energy deployment in Indian states.

These studies describe the importance of RE promotion policies for renewable electricity deployment, but also the need for renewable energy endowments, and the effect of electricity trends, other energy policies, political institutions, interest groups, socioeconomic characteristics and external stimuli. We will assume that these factors affect in the same way the deployment of RE within the CDM in developing countries.

In terms of **RE promotion policies**, it is frequently argued that feed-in tariffs (FITs) have been the most effective policy for achieving capacity goals, as they are very good at providing market certainty and setting incentives for electricity production. Successful experiences have been seen in Denmark, Germany and Spain. Renewable portfolio standards (RPSs) establish a quota for RE contribution to electricity production, and are the main type of non-financial RE promotion instrument. Although they provide less market certainty than FITs, if coupled with renewable energy certificates they can promote competition and cost reductions. Their effectiveness depends on reliability of the target and on other policies that improve renewables' competitiveness. This system is mainly being applied in industrialized countries, such as the UK and several US states. Investment-based or production-based incentives have been effective as complements to other, stronger policies (Menanteau et al. 2003; Gan et al. 2007; Butler and Neuhoff 2008). Accordingly, we hypothesize that the existence of RE promotion policies in a country leads to increased RE deployment, and that the more of these

[43] The more general literature analysing the determinants of Foreign Direct Investment (FDI) is also relevant for the case of investment in RE in developing countries, although it usually focuses on the manufacturing sector. This literature finds market size (measured as total GDP or GDP/cap) as the most robust factor affecting foreign investment flows positively, but it also suggests that infrastructure, level of industrialization, labour costs, political and economic stability are important, with evidence mixed on trade openness and the role of more specific investment-related policies and regulations, such as fiscal incentives. As will be seen below, most of these factors are also recognized by the more specific RE investment and the CDM project distribution literatures as relevant. Others, for example labour costs, will matter for manufacturing industries that are export-oriented, but not necessarily for electricity infrastructure, which is always for the domestic market. See Root and Ahmed (1978; 1979), Lim (1983), Schneider and Frey (1985), Crenshaw (1991), Singh and Jun (1995), Tsai (1994), Gastanaga et al. (1998) and Bénassy-Quéré et al. (2007) for empirical examples of the FDI literature, and Lim (2001) for a review.

policies are in place, the more complementarities are likely, and the better the support for RE deployment is.

Still, even if the policies to promote RE deployment are in place, these energies rely heavily on **natural endowments**, such as sun irradiation or strong wind, which need to be present in sufficient quantity and quality to make the investments competitive (Bird et al. 2005). Thus, we will add measures of renewable energy potential as controls, expecting that the more potential is available, the more renewable energy can be deployed.

Furthermore, the deployment of new electricity plants will clearly be affected by the trends in electricity markets. If demand is already satisfied, the market for new power plants will be limited to just replacing old and inefficient installations; if demand is growing, more capacity will be needed. Associated with electricity trends are the costs of substitute technologies – e.g. conventional thermal power generation. Volatile or rising fossil fuel prices make renewables more competitive and attractive for utilities, and may make governments more willing to promote renewables due to **energy security concerns**, especially if they rely on fuel or electricity imports (Bird et al. 2005; Marques et al. 2010). Indicators of unsatisfied electricity demand and of energy security concerns may thus also be needed as controls with a positive effect on RE deployment.

Stable **political institutions** are needed to attract investors: they need certainty that the incentives provided today will be in place tomorrow, so that the return to their long-term investments is secure. Authors have also discussed that democracy leads to better institutional performance and thus create a more favourable business environment (Benecke 2009). Thus, we expect that indicators of democracy and of political stability and effectiveness will result in more investment in RE.

Socio-economic characteristics may also affect the affordability of RE and the preferences of the consumers. Higher income levels usually lead to stronger environmental preferences of the population and could lead to increased demand for cleaner energy sources (Elliott et al. 1997; Vachon and Menz 2006). They also enable the government, through tax revenues, to enact and implement costly policies such as those involving RE support. Finally, income and, more specifically, the availability of capital, determine a country's capacity to invest in infrastructure projects such as power plants (Martinot 2002; Lütken and Michaelowa 2008; Marques et al. 2010).

Benecke (2009) identifies foreign direct investment (FDI) and the Clean Development Mechanism as sources of **external stimuli** for RE deployment. FDI is a channel of finance, technology and know-how related to new technologies such as RE. The CDM, as a supra-national governance structure that sets up financial incentives for low-carbon technologies in developing countries, not only provides external finance, but also generates awareness of climate change as a problem and renewable energy as a potential solution; an international market for emission reductions that looks for supply from developing countries; and substantial capacity building. In our case, where the focus of analysis is the investment in renewable energy through the CDM, we will consider that the more open an economy is towards FDI flows, the more open it will also be towards CDM investment.

Factors influencing the geographical distribution of CDM projects

There is a growing body of literature that deals generally with the barriers existing for CDM investment in developing countries, and more specifically with the geographical distribution of CDM projects. Ellis and Kamel (2007) describe four general types of barriers that may prevent CDM investment: policy or legislative, CDM-related, financing and international barriers. The study shows, among others, that a stable regulatory framework and a clear and enabling CDM-specific policy framework are needed to spur CDM investment.

In terms of general regulatory framework, we have seen above that a stable institutional framework is needed for attracting investments, and this is also true for the CDM. With regard to the **CDM-specific policy framework**, two fundamental preconditions for CDM investment are that the host country has ratified the Kyoto Protocol and that it has established a national CDM authority (the Designated National Authority or DNA), with a clear process for the national approval of CDM projects. We thus expect that the earlier these preconditions were fulfilled, the higher the interest of the host country is on the CDM, and the more time it has had to propose CDM projects.

A body of empirical research already shows that host country circumstances matter for the level of participation of the country in the CDM. In their study, Dolšak and Bowerman (2007) demonstrate the importance of **bilateral relationships** – trade volumes or past colonial ties – for the development of bilateral CDM projects. We hence expect that trade volumes, past colonial ties, FDI levels and aid levels may positively influence CDM investment in a country.

In terms of **socio-economic characteristics**, Flues (2010) finds that especially economic development (operationalized as GDP per capita), growth and population have a significant positive impact on the amount of CDM projects being pursued in a country. Winkelman and Moore (2011) conclude that countries with growing electricity markets and high carbon intensity generate more CDM-related emission reductions. Three arguments may be at play here. On the one hand, income and growth are indicators of the availability of resources to finance CDM investments,[44] in a similar way as explained above. On the other, growth, but also population size, carbon intensity and other general indicators of the size of the economy indicate the existence of emission reduction opportunities (abatement potential). Finally, they create incentives for foreign investors to enter these attractive markets, which is relevant for the case of bilateral CDM projects. The three mechanisms play in the same direction: we expect that the larger the income and growth, the more CDM projects will be proposed. With respect to the specific influence of abatement potential, we also consider variables that more directly characterize the potential in the electricity sector, and also expect a positive effect of them on RE CDM projects.

[44] While it can be argued that CDM projects can also be developed bilaterally, with participation of investors from industrialized countries, many CDM projects, especially RE ones, are proposed unilaterally, this is, only with participation of domestic investors (for a detailed discussion of the reasons, see Lütken and Michaelowa 2008). Flues (2010) finds that the positive effects of GDP and growth on the likelihood that a country develops a CDM project are stronger for unilateral than for bilateral projects, supporting this theory.

Factors leading to the adoption of environmentally-friendly policies

An empirical challenge in the use of renewable energy support policies as an explanatory variable for the amount of CDM RE investment is that the direction of the causal link between RE support policies and CDM investment is not completely clear. It is likely that, after RE support policies were already in place, the CDM provides an additional incentive that results in more deployment. This is what we are trying to model. But it is also possible that, in some countries, the prospect of having the CDM led the government to enact other supportive measures that would be complementary. In both cases, the result would be (increased) RE investment within the carbon market, but the RE policies would have to be treated as exogenous in the first case, and as endogenous in the second. To address this issue, we will also apply an instrumental variable approach. The literature review in this section is used to search for variables that may become suitable instruments for the RE support policies.

Several theories seek to explain which factors affect the adoption of public policies. Developmentalists argue that socio-economic factors determine the scope of policy outputs and outcomes that are possible; institutionalist approaches posit that the political institutions and organizations, such as the legal systems, the legislative and the bureaucracies structure policy decisions and outcomes; rational choice theory emphasizes the role of preferences and interests of different actors for decision-making and policy outcomes; sociological perspectives underscore the role of formal and informal relationships and networks within and outside of the political system in determining policy outputs and outcomes (John 1998). We will make use of these theories to find instruments that help us deal with the potential endogeneity of RE support policies in our empirical estimations. However, many of the factors that affect policy adoption are the same as those that affect CDM RE investments. Suitable instruments need to be correlated with support policies but not directly with CDM RE investments. Hence, we discard variables related to environmental pressures, wealth, level of education and democratic quality, as these are expected to influence both policy-making and the investment in CDM renewable energy projects, and focus our search for instruments among the institutional and interest-related factors.[45]

Institutional theories posit that the **characteristics of the political system** influence policy adoption. There is an extensive literature on the effect of fractionalized political systems and of the number of veto players on policy adoption (Tsebelis 1995; Tsebelis 1999), arguing that the more decision-making instances are involved in agreeing a new policy, the less able is a government to adopt it. These theories have also been applied to the study of environmental policy adoption, for example by Knill et al. (2010) and Ashworth et al. (2006). The attractiveness of this theory is that it is applicable to any type of political regime, not only to democracies, and is thus more applicable to developing countries.[46] It is also more suitable as an instrument than democratic quality, as

[45] See Stadelmann and Castro (2012) for a more detailed review of the factors expected to affect policy-making in support of renewable energies.

[46] Partisan preferences are also usual predictors of environmental policy adoption (see e.g. Lester et al. 1983; Rohrschneider 1993; Neumayer 2003; Carter 2007; Tosun 2011). However, as party systems are not so developed in developing countries, and data on partisan preferences is not available for them, we have not used this variable in our empirical analysis.

democracy is also expected to affect CDM investments by improving the country's business environment (Benecke 2009).

Not only may the types of institutions existing in a country influence policy adoption, but also the **ability and capacity of the institutional actors**. Lester et al. (1983) and Ringquist (1994), for example, hypothesize that more professional legislatures have more resources, time and capacity to deal with complex environmental problems and thus develop more innovative and comprehensive policy solutions. Sapat (2004) argues that the human resources quality within the bureaucracy influences policy adoption. We thus expect that countries having more agencies dealing with energy, air quality or climate change issues will be better prepared to adopt RE-related policies.

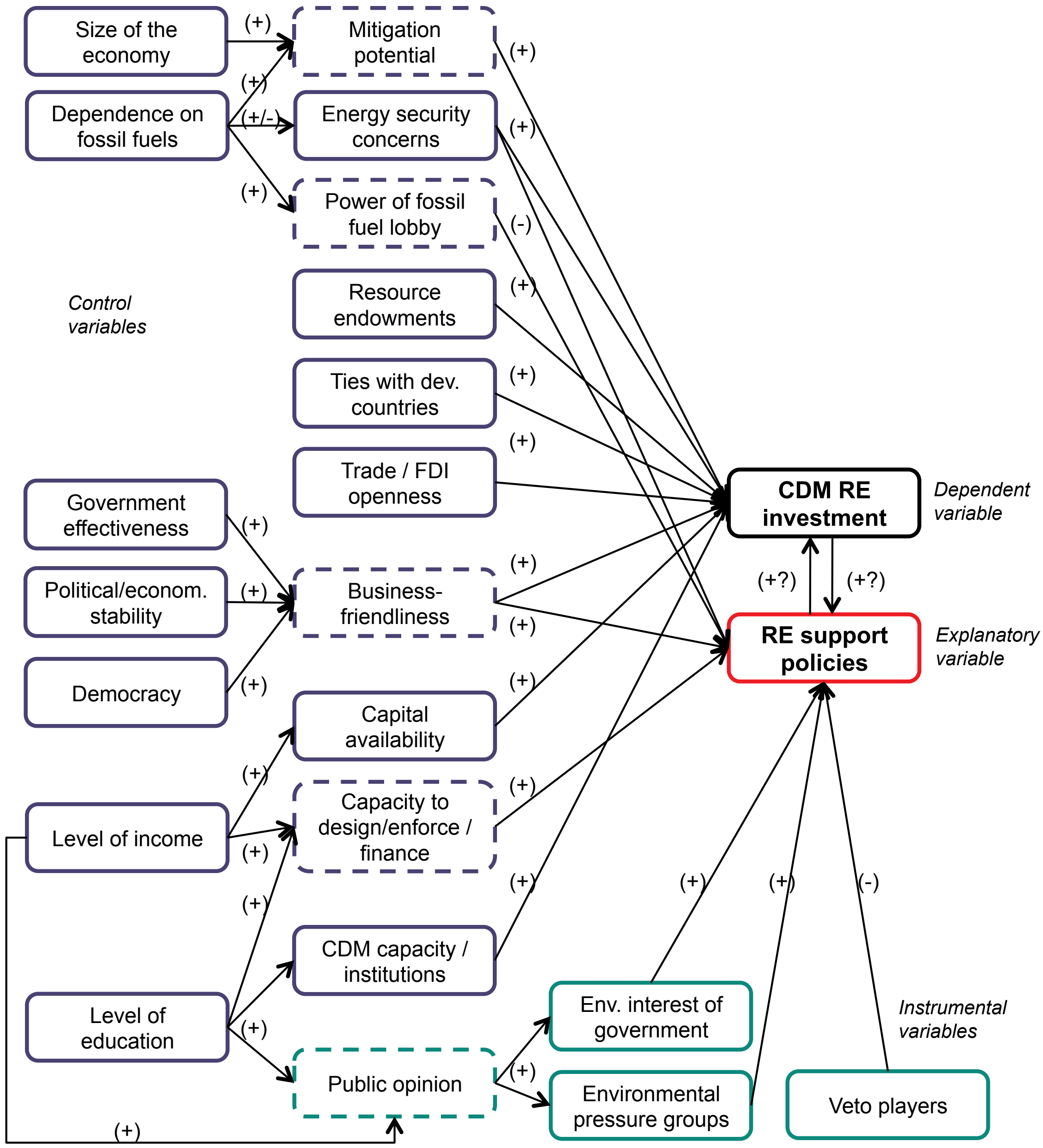
As explained by rational choice theory, the **interests and preferences of actors** influence policy outcomes, and this is true also in the environmental domain. Congleton (1996) summarizes the role of voters, organized lobby groups and members of the government (legislators and bureaucracy) in devising environmental policy. Several studies (e.g. Ringquist 1994; Sapat 2004; Michaelowa 2004; Fredriksson et al. 2005; Vachon and Menz 2006; Marques et al. 2010) have analysed empirically the role of different lobby groups on environmental policy-making. Within the subfield of renewable energy promotion, while many stakeholders may be affected by such measures, those directly involved in the energy sector should be most important. It has been thus hypothesized that the polluting industry, in this case, fossil fuel producers, will seek to avoid regulation that imposes costs on them or, equivalently, that benefits their competitors (renewable energy producers). Hence, fossil fuel producer countries are likely to be subject to lobbying that reduces the chances of adopting RE support legislation. As fossil fuel production is expected to also influence CDM RE investments due to its importance for energy security concerns, it cannot be used as instrument.

The strength of environmental groups has been positively linked with more or stronger environmental policy, including policies that support the deployment of RE energy (Fredriksson et al. 2005; Vachon and Menz 2006). It can be argued that environmental groups also lobby for or against specific investments that affect local environmental or social quality, and would thus potentially influence RE investment. This is specifically a concern for large hydro power projects, which may result in displacement of local populations and are thus opposed by environmental groups. As the CDM has a requirement to consult with relevant local stakeholders before project implementation, and as the main buyer, the EU, imposes further quality conditions on large hydro projects, we believe that the relevance of this aspect is, in the context of the CDM, limited. Thus, we expect that countries with high presence of environmental groups will be more likely to adopt RE support policies, and will use the amount of environmental groups existing in each country as an instrument for policy adoption.

Ecological preferences of decision-makers and the public have been shown to be positively correlated with environmental policy-making (List and Sturm 2006; Vachon and Menz 2006; Knill et al. 2010). As we do not have a direct measure of ecological preferences for all countries included in our sample, we consider several local environmental quality indicators to proxy the level of environmental preferences of the public and the government. The rationale behind this is that a government that generally cares about the environment is expected to also care about deploying more RE, and thus adopt policies to promote it. A possible concern is that a government with strong environmental preferences, including preferences for mitigating climate change, may also exhibit a strong support for the CDM. However, this support does not directly translate into more projects, but into an enabling framework for the CDM, such as the establishment of a good DNA with a rapid project approval process, a CDM promotion office, and the promotion of capacity building efforts to facilitate CDM project development. Many of these factors are already controlled for in our analysis by taking into account variables that characterize the government's effectiveness. Capacity building is not accounted for, because data are not available for all countries, but research on capacity building for the CDM shows that capacity building follows donors' interests (Okubo and Michaelowa 2010; Stadelmann and Michaelowa 2011), and that its effectiveness varies substantially, even within a relatively developed country like China (Schröder 2009; Stadelmann and Michaelowa 2011). CDM project development itself is, in the case of RE, in the hands of utilities or private sector investors. Thus, their decision to invest in RE projects (and to submit them as CDM projects) will depend rather on energy needs, resource availability and project economics than on the preferences of the government, except if these preferences translate into specific policy-making, which is what we are trying to instrument with these environmental quality indicators. Therefore, we expect that our environmental quality indicators will not affect RE CDM projects directly, and can be used as instruments for the adoption of RE support policies.

The theoretical expectations described in this section are summarized in Figure 6.1, which maps the direct and indirect factors that may affect both the enactment of renewable energy promotion policies and the investment in renewable energy CDM projects in a country. It is these factors that the variables for the empirical assessment will be drawn from. Factors for which no suitable variables have been found, are marked with a dashed border. Instead of these factors, however, we will either control for the underlying causes or for more specific manifestations. The expected effect of these factors, either on renewable energy CDM investment or on the adoption of renewable energy support policies, is indicated with a (+) or a (-). We choose the control variables for this study among those factors that are expected to influence both CDM investments and RE support policies (in blue), while the instrumental variables are those that only affect the policies directly (in green).

Figure 6.1: Factors affecting the adoption of RE CDM investment and RE support policies



6.4 Data

6.4.1 Dependent variable

The dependent variable is the size of the CDM investment in renewable energy projects in country *i* using a specific technology *j* at time period *t*, measured in MW of energy capacity proposed to be installed in each period. The source of this data is the CDM Pipeline database published monthly by the UNEP Risoe Centre, in its January 2012 version (UNEP Risoe Centre 2012).

Table 6.2 shows the renewable energy technologies included in the study, the amount of projects currently registered, the total projects in the pipeline (under validation, requesting registration and registered), and the amount of countries that have proposed such CDM projects. Technologies are defined on the basis of data on project types and project subtypes included in the CDM Pipeline.

Table 6.2: Renewable energy projects under the CDM

Technology	Number of projects registered	Total projects in pipeline	Number of countries hosting projects
Biomass energy	320	619	36
Geothermal	12	21	9
Hydro small (≤20MW)	665	1142	42
Hydro large (>20MW)	462	846	37
Landfill gas – power	106	209	31
Solar photovoltaic	46	155	13
Solar thermal electric	2	4	3
Tidal	1	2	1
Wind	902	1921	38
Total	2516	4919	73

Source: UNEP Risoe Centre 2012
Note: Bold letters highlight those project types that will be included in separate empirical estimations.

While Table 6.2 displays the variety of renewable energy technologies that are being deployed through the CDM, it also makes clear that several of them are still represented by very few projects. We hence first aggregate the data into a dependent variable including all these RE technologies together, and have additional specifications looking specifically at wind, small hydro,[47] biomass and photovoltaic power plants. Technologies with very few observations are excluded from this separate analysis, as well as landfill gas power projects, because these are closely linked to requirements, policy-making and actual practice about waste management, which is out of the scope of this study.

We have specified the dependent variable in terms of projects submitted for validation (instead of projects already registered) for theoretical reasons: our aim is to assess whether domestic policies are having an effect on the amount of renewable energy CDM projects being proposed. By taking

[47] For the specification looking at only hydro power, we have only included those projects with up to 20 MW of installed capacity. We focus on this subsample of projects because in several countries, promotion policies are directed specifically to small hydro projects. Because the definition of what is a small hydro project varies from country to country, our classification is somewhat arbitrary from the theoretical point of view. We chose 20 MW as a threshold because it nicely fits the frequency distribution of hydro projects by size: this distribution clearly has two peaks, one for small projects and one for large ones, with 20 MW representing a suitable separation between both peaks. A plausible explanation for this distribution is that the EU Commission, which regulates the main buyer market for CDM credits, decided that CERs from hydro projects larger than 20 MW would only be accepted in the EU ETS if they have been approved by the World Commission on Dams. As this is an additional step in the project cycle associated with extra transaction costs, project developers may not be willing to go beyond this size. Furthermore, 15 MW is the limit established by the CDM regulations for being allowed to use small-scale methodologies for energy projects, which may explain the higher frequency of projects up to this size.

submitted projects, we avoid including the effect of the complex CDM registration cycle and its regulatory barriers, and keep a cleaner link with country-level determinants (see Chapter 1 for a description of the CDM project cycle). The variable is expressed in terms of MW of power capacity installed by the CDM project, because considering only counts of projects would disregard the importance of project size. On the other hand, considering the emission reductions would generate a bias, as emission reductions are calculated on the basis of countries' existing energy system and its grid emissions factor.

The data is a panel that covers the period in which the CDM has been active (from 2004 to 2011), for 147 developing countries that have ratified the Kyoto Protocol.

6.4.2 Explanatory variables

Renewable energy promotion policies

As explained above, there are several types of policies providing direct financial support for RE. As each of these policies can be designed in many different ways, there is no clear theoretical argument for distinguishing which of them is more effective in terms of RE deployment. Consequently, in order to capture the effect of all these policies and of possible complementarities between them, we create a variable that counts the amount of policies in place in each country in a specific year. We generate dummies for ten general types of RE promotion policies, as they are classified in the REN21 reports and shown in Table 6.1. The dummies indicate whether these policies are in place in the respective country, but they do not specify which renewable energy technologies they are applicable to. Still, they provide a clear indicator of a country's level of effort to support RE deployment. This information is available every two years from the REN21 reports (2005, 2007, 2009, 2010, 2012). We thus have created a panel with this data, assuming that, if in year t and in year t+2 a policy was in place in country i, then in year t+1 it was also in place in the same country. In years where there is a change in policy (e.g., policy in place in year t, but no longer in place in year t+2), we have filled the gap with a 0.5. The years before 2005 have been filled with the same information as in 2005. After having a complete panel, we have created a general RE support variable by adding up the dummies for all ten types of policies, with possible values between zero and ten. The higher the value is, the more RE support policies exist in the country, and the more favourable the conditions for RE investment are supposed to be. This explanatory variable was lagged by one year to account for the fact that the planning phase of a RE project usually takes several months if not years; so, if a policy signal is to be taken into account, it needs to be present already well in advance of the CDM phase, which typically takes place once all feasibility studies for the project are completed. Additionally, lagging the policies variable would to some extent ease the concern that the adoption of support policies is affected by the investments taking place, so that, under the assumption that there is no autocorrelation in the data, it would reduce the concerns about endogeneity arising from reverse causality problems.[48]

[48] Note however that this approach would not control for endogeneity that arises from the fact that there may be unobservable variables that affect both CDM investment and RE support policies.

Still, we chose to use an instrumental variables approach to control for the possible endogeneity of the policies variable. According to the literature described above, general environmental quality indicators should be correlated with stronger RE support measures and not directly correlated with the CDM RE investment. Among several potential variables tested in preliminary analyses, we choose the percentage of country population with access to an improved water source, obtained from the World Development Indicators (WDI) (World Bank 2012), as a first instrument. The choice relies on the statistically observed strength and validity of the instrument, but also on the theoretical intuition that governments that care more about safe water provision are more likely to also care more about provision of clean sources of energy, but due to the completely different economic sector involved, it is not likely to have a relationship with CDM project investments. As a second instrument, we chose the country-level concentration of particulate matter in the air (PM10 in micrograms per cubic meter), obtained also from the WDI (World Bank 2012). This was also found to be a valid and strong instrument related to the propensity of the country's government to care for air quality.

The other chosen instruments are related to the existence of civil society or public stakeholders that support environmental regulation or regulation in the energy and air quality domains. Data on the number of environmental NGOs present in the country was compiled from the Environment Encyclopedia and Directory (Europa Publications 2000; Hartley et al. 2009). This data was available only for the years 2001 and 2010 and interpolated for the years in between. As a more robust variable, hence, we also use the number of international NGOs with members in the country as an alternative instrument; this data is available for all years and was retrieved from the Yearbook of International Organizations (Union of International Associations 2012).

Other instruments, measuring different environmental qualities and types of environment-related stakeholders in the countries, as well as indicators of political activity and cycles, including number of veto players, indicators of type of regime, electoral years, vote share of the opposition and level of fractionalization in the legislative were also tested. Either their strength was too limited, or they were not considered as valid instruments after a test of overidentifying assumptions.

As the policies variable is used in lags, the instrumental variables were also lagged by one year.

<u>Controls</u>

We control for the other factors identified in the literature that could influence CDM investment and/or the adoption of RE promotion policies. To control for the effect of the power of the fossil fuel lobby, we measure the country's overall production of fossil fuels (coal, gas and oil) in relation to its GDP. We normalize using GDP because otherwise the variable is highly correlated with other variables that seek to control for the size of the economy, like total GDP. This variable may also be a proxy for competitiveness of renewables: the more fossil fuels a country produces, the less competitive in terms of costs we expect renewables to be. The data for fossil fuel production are taken from IEA (2012b) and GDP is from the WDI (World Bank 2012).

Energy security concerns are measured by adding up the imports of electricity, coal and gas (in tonnes of oil equivalent per US$ of GDP). The rationale is that higher dependence on imported fuels for electricity production (we assume that oil is not usually used for producing electricity) or on imported electricity will lead governments to increase support for domestically produced renewable energy. The data for fuel and electricity imports are obtained from the US EIA (2012).

Mitigation potential is modelled both through the emissions intensity of electricity and heat generation, and through the natural resource endowments for renewable energy. Data on CO_2 emissions per kWh of electricity and heat generation are obtained from IEA (2012a). For the specification including all RE technologies together in the dependent variable, the most suitable indicator of natural endowments is the country's surface area: it should be able to proxy for area that could be used to capture solar energy; the more area a country has, the more likely it is that it will have good wind resources somewhere; the more area it has, the more area under crops or managed plantations is likely, which can provide biomass. Thus, the natural logarithm of the total surface area, obtained from the WDI (World Bank 2012), has been used as proxy for natural endowments.

For the specifications looking at individual RE technologies, data on renewable energy endowments come from a variety of sources. For wind energy, we use data from the NASA Surface meteorology and Solar Energy Data Set (NASA 2005) on the percentage of time that the wind speed at 50 metres above the surface is above 6 m/s. The data are provided in a 1x1 geographical degree grid, which we have plotted against country coordinates to obtain a maximum value for each country in our dataset. For solar energy, we use data on latitude tilt radiation (in kWh/m^2/day) from NASA (2008), which has been plotted in the same way as the wind speed data. For hydro power we use data on average annual precipitation from IPCC (Hulme 2001), obtained through the GEO Dataportal, and data on altitudinal difference from the CIA World Factbook (Central Intelligence Agency 2010). For biomass energy, we use data on the area covered with permanent crops (in thousands of hectares) from FAOSTAT. Other variables measuring the area under temporal crops, under sugar cane plantations and under forest plantations were tested, but they were available for far fewer countries or were too highly correlated with the previous ones.

CDM awareness and technical capacity are modelled by two variables: a dummy indicating whether a national CDM authority (DNA) is in place, and a dummy indicating the years in which the country has had a member in the CDM Executive Board.[49] The first variable signals both preparedness and interest in pursuing CDM projects, and was obtained from Axel Michaelowa (personal communication) and completed using the UNFCCC website; the second one tries to capture possible knowledge transfers from having a representative in the CDM's international regulator. This variable was found by Flues et al. (2010) to be significantly related to project registration in a country. The data was obtained from Flues et al. (2010) and updated up to 2011 by looking at the reports of the CDM Executive Board meetings.

[49] We do not include the variable indicating ratification of the Kyoto Protocol that was discussed in section 6.3, as this variable is a perfect predictor of having CDM projects. But we exclude all countries that have not ratified the Kyoto Protocol from our sample.

Two variables measure possible ties with industrialized countries. The sum of imports and exports as percentage of GDP is used to measure openness to trade, which is a usual indicator of insertion in the world economy. Net foreign direct investment (FDI) inflows, as percentage of GDP, signals openness towards foreign investors, which is important for the CDM, which presupposes international flows of finance. These data are obtained from the World Development Indicators (World Bank 2012).[50]

The quality of democracy in the country is measured using the Freedom House Polity 2 index, obtained from Teorell et al. (2011). Additionally, to capture the business-friendliness and stability of the economy, we include the indicators for government effectiveness and political stability from the Worldwide Governance Indicators (Kaufmann et al. 2012).

The level of education is measured through the mean years of schooling of the population with age 25 or more, obtained from the Human Development Report (UNDP 2010). We also control for the size of the country's economy (measured as the natural logarithm of the real GDP, to correct for skewness), income (log of real GDP per capita), gross fixed capital formation and GDP growth, variables that are expected to capture the mitigation potential in the country, the capacity to invest and the need for energy resources, respectively. The data was obtained from the World Development Indicators (World Bank 2012).

Appendix 6A includes the descriptive statistics of all variables included in the analysis for both the original and the imputed dataset, and a correlation table for the imputed data.

6.5 Empirical strategy and results

The dataset has a rather complex structure, consisting of a short panel, with a substantial amount of missing values (in developing countries, data is often not regularly updated or not available for all years). The dependent variable – the MW of renewable energy deployed through the CDM in country i using technology j in year t – is left-censored (there cannot be any negative values of renewable energy deployment) and highly skewed. To reduce the skewness, the lognormal transformation recommended by Cameron and Trivedi (2009, p. 532) was applied, in which the zeros are added back to the dataset once the positive data is log-transformed. All regressions were run on this log-transformed dependent variable. Two-part and Heckman selection models were used to model the effect of RE support policies on the size of the renewable energy CDM portfolio in each country.[51] These models were chosen in consideration of the possibility that there are actually two different processes leading to CDM investment in renewable energy in a country: first, the

[50] Colonial history and aid relationships were also tried as possible indicators of ties with industrialized countries, but they were never found to be significant. Data for colonial history were obtained from the Quality of Government dataset (Teorell et al. 2011), and for net official development assistance and official aid received from the WDI (World Bank 2010).
[51] Tobit models were used in preliminary regressions; due to the strong assumptions of the tobit model, however, only the results of the more general two-part and selection models are presented here.

decision in a country to engage in RE investments within the CDM at all is ruled by a specific process (the selection equation), and then, another process, with the same or other variables being relevant (and with the same variables potentially having different effects) determines how much renewable energy is deployed through the CDM in the country (the outcome equation). This approach follows a similar rationale as the one used by Flues for general CDM investment (2010), and consists of first estimating a probit or logit model on the likelihood that country *i* has submitted at least one CDM project employing renewable energy technology *j* during period *t*, $pr(y=1)$, against the likelihood that it has not, $pr(y=0)$. The outcome equation uses standard OLS to assess, for those countries that have submitted at least one CDM project, what factors affect the amount (in logs) of renewable energy deployed in that period. A problem found with this specification is that we have relatively few strictly positive observations for some of the technologies analysed. As a result, the estimations for the positive part of the models have few degrees of freedom.

To deal with the problem of missing values, Stata's new multiple imputation commands were used. Three different types of imputation models were compared: linear regression, chained equations with linear regression, and chained equations with predictive mean matching (PMM). They all performed similarly in preliminary regressions across all non-IV models. The imputations using PMM were eventually chosen for the analysis in this chapter, because the dataset has several variables that are clearly bounded (e.g. GDP, agricultural area, population or years of schooling with strictly positive values), which were modelled better by this algorithm. Ten imputation datasets were used, and inferences were made by using Stata's *mi* commands to combine the results in all of them following Rubin's (1987) rules for aggregating imputed datasets. Using multiple imputation increased the number of observations substantively (from 321 to 926). Regressions using the imputed data were compared with regressions with the original data. This comparison shows that as the number of observations increases, so does the significance of the estimated effects. But the direction of the effects and the variables that seem to matter most remain consistent across the models with and without imputations. As Stata's *mi* commands are still fairly limited in terms of the postestimation statistics that can be calculated, regressions with just one imputation dataset were used for making tests of random versus fixed effects, and for testing the validity and strength of the instrumental variables.

The regressions were estimated, whenever possible, in panel specifications. A test of overidentifying restrictions using the artificial regression approach described by Wooldridge (2002, p. 290) was used instead of the usual Hausman test to decide between random and fixed effects models (Stata command *xtoverid*, developed by Schaffer and Stillman 2010). This solved problems of negative test statistics and violation of assumptions of the Hausman test. Our interest lies in the effect of domestic RE support policies on CDM RE investment. Both our main explanatory variable and our dependent variable vary mainly across countries. Furthermore, once policies are adopted, they are likely to stay in place, and hence the variation of our main explanatory variable within units over time is small. This all speaks for a preference towards random effects models, which include both within and between variation in the estimation, so that random effects will be applied wherever they are found to be suitable according to the test. As a robustness check for the random effects specification, we also show models including the Mundlak (1978) correction for potential correlation between the regressors and the country-level errors, which consists in adding to the list of regressors also country-level means of all time-varying variables (correlated random effects model).

Time fixed effects were included in all models to control for potential shocks and general heterogeneity across time. The CDM is a volatile market, subject to external influences that cannot be fully controlled for otherwise. Time fixed effects are correspondingly significant.

Finally, instrumental variable (IV) estimation was used to cope with the potential endogeneity in the RE support policies variable. IV was applied only for the two-part specifications, as this is the model that generated more reliable results. In the selection equations (the binary part of the two-part model), the IV regression is implemented in two ways: first, using the Rivers-Vuong (1988) control function approach as described by Wooldridge (2010, p. 586-87), which implies first regressing the policies variable against all explanatory variables and the instrument(s), and then using both the original policies variable and the residual from the first-stage equation in the main regression. The advantage of such an approach is that it allows for a direct test of the exogeneity of the instrumented variable: if the residual is found not to be statistically significant in the main regression, then the hypothesis that the instrumented variable is exogenous cannot be rejected. In addition, this method allows us to use random effects probit in the main regression and hence use the panel structure of our data. The disadvantage of this two-step approach, which was implemented manually in Stata, is that we are not able to adjust the standard errors to account for the sampling variability in the first-stage estimation of the residual. Hence, we also apply a pooled maximum likelihood IV probit using clustered errors and controlling, as above, for the country-level means of all time-varying regressors, as suggested by Wooldridge (2010, p. 630-32).

In the outcome equations (the positive part of the two-part model), the panel IV regression was implemented directly using the *xtivreg* command in Stata. In addition, again to avoid the random versus fixed effects debate, we estimated correlated random effects models (Mundlak 1978; Chamberlain 1980; Chamberlain 1982), both with normal and with clustered standard errors.

The strength of the instruments was assessed using their predictive power in the first stage regression. Preliminary regressions (not reported) led us to discard several of the potential instruments considered, due to their weak correlation with the support policies variable. Only the regressions using instruments that were found to have sufficient predictive power are reported.

All these models were run for a specification that includes all types of RE technologies listed in Table 6.2 in the dependent variable (so, the dependent variable becomes the logged MW of total RE capacity that has been proposed through the CDM, in country *i*, in year *t*). Once a final model was found, this was applied to specifications with four individual RE technologies: wind, biomass, small hydro and photovoltaic power.

Results: All renewable energy technologies in aggregate

Table 6.3 presents the regression results for the selection equations, hence, for the effect of RE support policies on the likelihood that countries submit RE projects to the CDM at all. Tests of random versus fixed effects indicated that random effects models are appropriate, hence only such models are reported in the table. Table 6.4 presents the results for the outcome equations, i.e., for the effect of RE support policies on the amount of renewable energy deployed by countries through the CDM. Here, the test of overidentifying restrictions (test of random versus fixed effects) suggests that fixed effects models are necessary. We hence report the results of fixed effects regressions, in which the estimations only rely on the within-country variance over time, but also the results of correlated random effects models.

The Heckman selection model is only available in a pooled version in Stata, so only pooled results are reported. As the Mill's ratio was never found to be significant, we are confident that the two-part regression in panel specification is more suitable than the Heckman regression to model the determinants of CDM RE projects.[52] Hence, we rely on the simpler two-part models for the instrumental variables (IV) estimations. The results of the first-stage regressions for the IV specifications can be found in Appendix 6B, Tables 6B.1 (outcome equations) and 6B.2 (selection equations).

We have seven models for the selection equation (Table 6.3): a random effects probit (regression (1)); a correlated random effects probit, which allows us to correct for the potential correlation between the random effects and the other regressors (model (2)); the selection equation of a pooled two-step Heckman model (3); and four IV models: the Rivers-Vuong control function model and the maximum likelihood pooled IV probit with the instruments *water access* and *international NGOs* (models (4) and (5)), and the same two IV models with the instruments *water access* and *environmental NGOs* (models (6) and (7)). We show results for these two sets of instruments because they differ in their strength and in the assessment of the endogeneity of the instrumented variable. While in both cases the instruments were found to be valid according to the test of overidentifying restrictions, in models (4) and (5) the instruments are very strong according to the first-stage statistics, and the instrumented variable *RE support policies* is found to be endogenous according to the Smith-Blundell endogeneity test. In contrast, the instruments used in models (6) and (7) are somewhat weaker, and in this case the endogeneity test indicates that the *RE support policies* variable is exogenous. Hence, we cannot conclude with certainty whether there actually is an endogeneity problem.

[52] Heckman models with an additional selection variable (Kyoto Protocol ratification, as only parties to the Kyoto Protocol can participate in the CDM), or with the DNA variable only in the selection equation (having a national authority for the CDM is relevant for a country being able to participate in the CDM, but it should not impact the amount of CDM investment it has), did not change the results substantially, and the Mill's ratio remained insignificant. We only report the baseline model with the same explanatory variables as the two-part models.

Table 6.3: Effect of RE support policies on the likelihood that RE projects are submitted for validation to the CDM (selection equations)

MODEL	(1)	(2)	(3)	(4)	(5)	(6)	(7)
	RE probit	Correlated RE probit (Mundlak correction)	Pooled Heckman, two step	Rivers-Vuong IV with RE probit	MLE pooled IV probit	Rivers-Vuong IV with RE probit	MLE pooled IV probit
VARIABLES	normal errors	normal errors	normal errors	normal errors	clustered errors	normal errors	clustered errors
RE support policies (lag)	0.353 (0.096) ***	0.136 (0.124)	0.377 (0.0753) ***	1.148 (0.269) ***	1.134 (0.148) ***	1.100 (0.74)	1.081 (0.284) ***
RE support policies (country mean)		0.422 (0.205) **					
Fossil fuel production per GDP	-84.47 (272.1)	-51.64 (250.2)	-106 (265.1)	-78.23 (221.0)	-43.8 (141.1)	-81.83 (260.4)	-52.74 (186.9)
Member in the CDM EB	-0.56 (0.274) **	-0.779 (0.334) **	-0.478 (0.218) **	-0.605 (0.280) **	-0.184 (0.264)	-0.620 (0.274) **	-0.221 (0.405)
DNA established	0.923 (0.255) ***	0.637 (0.317) **	0.963 (0.209) ***	0.953 (0.258) ***	0.306 (0.204)	0.930 (0.262) ***	0.321 (0.260)
FDI inflows	-0.0528 (0.024) **	-0.0824 (0.030) ***	-0.0449 (0.018) **	-0.0547 (0.023) **	-0.038 (0.0196) *	-0.0474 (0.024) **	-0.0384 (0.033)
Total trade	0.0014 (0.003)	-0.0085 (0.0086)	0.00171 (0.0017)	0.00246 (0.0026)	-0.00437 (0.0045)	0.00203 (0.003)	-0.0058 (0.006)
Political stability	-0.147 (0.178)	-0.366 (0.454)	-0.0803 (0.114)	-0.0708 (0.179)	0.0285 (0.204)	-0.0689 (0.176)	-0.0144 (0.254)
Government effectiveness	0.476 (0.274) *	0.0238 (0.758)	0.296 (0.173) *	0.361 (0.265)	0.457 (0.381)	0.495 (0.268) *	0.363 (0.409)
Democracy	0.123 (0.043) ***	0.0447 (0.076)	0.113 (0.0307) ***	0.0663 (0.0465)	0.0295 (0.0456)	0.100 (0.056) *	0.0273 (0.050)
Mean years of schooling	0.143 (0.072) **	0.141 (0.184)	0.107 (0.0443) **	0.142 (0.0724) *	0.0424 (0.0833)	0.155 (0.071) **	0.0511 (0.107)
Total GDP (log, PPP)	0.447 (0.137) ***	1.099 (1.061)	0.385 (0.0887) ***	0.146 (0.160)	0.364 (0.463)	0.233 (0.275)	0.402 (0.655)
GDP per capita (log, PPP)	-0.438 (0.221) **	0.184 (1.003)	-0.291 (0.139) **	-0.403 (0.215) *	-0.446 (0.475)	-0.53 (0.222) **	-0.474 (0.662)
Capital formation	0.0569 (0.016) ***	0.106 (0.031) ***	0.0419 (0.0106) ***	0.0562 (0.0152) ***	0.0389 (0.0185) **	0.0491 (0.016) ***	0.0433 (0.039)
Gas, coal, electricity imports / GDP	1839 (2985)	22204 (13544)	916.9 (1757)	853 (2940)	7848 (5909)	-800.3 (3647)	8011 (9920)
Surface area (log)	0.0465 (0.094)	-28.48 (43.17)	0.0245 (0.059)	0.0444 (0.0923)	-8.523 (12.81)	0.0356 (0.09)	-6.601 (15.27)
Emissions from electricity and heat	-0.0005 (0.0004)	0.0002 (0.0007)	-0.00057 (0.0003) *	-0.00052 (0.0004)	-0.00004 (0.0004)	-0.00052 (0.000)	-7.55E-06 (0.000)
GDP growth	-0.0185 (0.023)	-0.0216 (0.027)	-0.0142 (0.0183)	-0.0165 (0.0224)	-0.00827 (0.0171)	-0.0179 (0.023)	-0.008 (0.018)
First stage residual (v2hat)				-0.886 (0.276) ***		-0.773 (0.751)	
Observations	926	926	926	926	905	906	885
Number of countries	123	123	123	123	120	120	117
Year fixed effects	YES	YES	YES	YES	YES	YES	YES
Controls for country means	NO	YES	NO	NO	YES	NO	YES
Instruments				Water access, International NGOs	Water access, International NGOs	Water access, Environmental NGOs	Water access, Environmental NGOs

Note: Standard errors in parentheses. In equations (4) and (6) they are not adjusted for the sampling variability of the first-stage estimation. Levels of significance are: *** 0.01; ** 0.05; * 0.10. The dependent variable is a dummy indicating whether the country has submitted a renewable energy CDM project for validation. Constants not reported.

Table 6.4: Effect of RE support policies on the amount of RE projects submitted for validation to the CDM (outcome equations)

MODEL	(8)	(9)	(10)	(11)	(12)
	Pooled OLS	FE 2SLS	Correlated RE 2SLS, Mundlak correction	Pooled Heckman, two step	IV FE G2SLS
VARIABLES	clustered errors	clustered errors	clustered errors	normal errors	normal errors
RE support policies (lag)	0.23 (0.115) **	0.259 (0.0807) ***	0.258 (0.089) ***	0.261 (0.082) ***	0.905 (0.493) *
RE support policies (country mean)			-0.183 (0.197)		
Fossil fuel production per GDP	-324.8 (616.1)	606.2 (5627)	-249.3 (946.8)	-413.5 (681.0)	1940 (8138)
Member in the CDM EB	0.318 (0.364)	0.646 (0.311) **	0.445 (0.315)	0.233 (0.318)	1.077 (0.568) *
DNA established	-0.391 (0.500)	0.623 (0.438)	-0.149 (0.472)	-0.127 (0.609)	0.146 (0.756)
FDI inflows	0.0734 (0.057)	-0.0608 (0.0477)	0.0273 (0.0548)	0.0648 (0.0456)	-0.0869 (0.073)
Total trade	0.00078 (0.004)	0.0299 (0.0157) *	0.0128 (0.0138)	0.00112 (0.0029)	0.0378 (0.0172) **
Political stability	0.215 (0.231)	-0.352 (0.560)	-0.689 (0.557)	0.175 (0.197)	0.0225 (0.787)
Government effectiveness	-0.199 (0.464)	-0.695 (1.123)	0.0934 (1.274)	-0.126 (0.320)	-0.637 (1.335)
Democracy	0.118 (0.072)	0.0703 (0.099)	0.105 (0.0999)	0.14 (0.0603) **	0.105 (0.121)
Mean years of schooling	-0.14 (0.107)	0.252 (0.381)	0.173 (0.325)	-0.126 (0.0834)	0.39 (0.436)
Total GDP (log, PPP)	0.558 (0.242) **	-13.73 (10.64)	0.504 (2.587)	0.617 (0.182) ***	-20.62 (12.00) *
GDP per capita (log, PPP)	0.109 (0.426)	19.47 (9.380) **	6.643 (3.403) *	0.0856 (0.279)	21.84 (10.16) **
Capital formation	0.0458 (0.0303)	-0.034 (0.0553)	-0.0772 (0.0549)	0.0545 (0.0288) *	-0.0102 (0.0675)
Gas, coal, electricity imports / GDP	-1382 (6833)	33757 (29804)	-2679 (21174)	-1736 (5858)	74634 (50893)
Surface area (log)	0.0796 (0.169)	-1217 (548.3) **	-203.9 (169.2)	0.0967 (0.123)	-1857 (792.4) **
Emissions from electricity and heat	6.63E-06 (0.0006)	7.19E-07 (0.001)	-0.000139 (0.0011)	-0.000137 (0.0005)	0.000358 (0.0014)
GDP growth	-0.0609 (0.0351) *	-0.0408 (0.0384)	-0.0713 (0.0329) **	-0.065 (0.0332) *	-0.0481 (0.0507)
lambda (Mill's ratio)				0.398 (0.515)	
Observations	208	208	208	926 (208)	208
Number of countries	61	61	61	123 (61)	61
Year fixed effects	YES	YES	YES	YES	YES
Controls for country means	NO	NO	YES	NO	NO
Instruments					Particulates, International NGOs

Note: Standard errors in parentheses. Levels of significance are: *** 0.01; ** 0.05; * 0.10. The dependent variable is the natural logarithm of renewable energy capacity of CDM projects submitted for validation. Constants not reported.

Throughout the eight models, a clearly positive and almost always strongly significant effect of our main explanatory variable (*RE support policies*) on the likelihood that a country proposes a RE CDM project at all can be observed. In model (2), after controlling for the fixed effect (the coefficient on the *RE support policies* variable), we see that the cross-country variability of the policies variable (the coefficient on the country mean for the *RE support policies* variable) is again positive and significant. In model (6), the instruments are relatively weak and hence the effect of the instrumented *RE support policies* variable appears to be weaker.

For the outcome equation (Table 6.4) we have five models: pooled OLS, fixed effects two-stages least squares, in both cases with clustered errors (models (8) and (9)); a correlated random effects model (10); the outcome part of the pooled Heckman model (11); and a fixed effects IV two-stage least squares model using the instruments *particulates* and *international NGOs* (model (12)). Endogeneity tests after the IV regression in this and alternative specifications reject the null that the instrumented *RE support policies* variable is endogenous. This is, IV regression is apparently not necessary at all in the outcome equation. Table 6.4 shows a consistently positive and significant effect of the main explanatory variable, *RE support policies*, on the amount of renewable energy to be deployed by CDM projects submitted to validation. These results hence support the hypothesis that the existence of domestic RE support policies is relevant both for the decision to propose a RE CDM project within a country at all, and for how much RE is to be deployed through the CDM; they are thus consistent with this chapter's argument that domestic RE support policies can be complementary to the CDM incentive in incentivizing more RE investment in developing countries.

Looking at the control variables, in terms of CDM-specific capacity and institutions we unexpectedly find a consistently negative effect of having a *member in the CDM Executive Board* on the initial decision to submit a CDM RE project (Table 6.3). One possible explanation is a time effect that we have not considered here: it is possible that, before applying for a position in the CDM EB, a country needs some expertise on the CDM, so that it will have EB members only once it has already proposed some CDM projects. However, in the outcome equations (Table 6.4), we do find that having a member in the Executive Board positively affects the amount of renewable energy investment deployed through the CDM, at least in the fixed effects specifications. Countries hence apparently tend to host more renewable energy CDM projects submitted for validation in the years in which they hold a seat in the Executive Board, which is consistent with our expectations. This positive effect, however, is no longer discernable in the pooled or correlated random effects models.

Having a national authority for the CDM (*DNA*) has a consistently positive and significant effect on the initial decision to submit a CDM RE project, but no significant effect on the amount of projects deployed. This is consistent with our expectations, as having a DNA is a pre-requisite for projects to be registered, but once a DNA is in place, this by itself has little effect on how many projects are proposed (it may be that some DNA's are more efficient and effective than others in approving CDM projects; this is however not measurable with our data).[53]

---

[53] As we are here looking at projects submitted for validation, the sample includes a few countries in which projects were submitted before a DNA was established (probably in the expectation that it would be established soon). This makes this

With respect to the variables representing international ties, FDI inflows has a negative effect on the initial decision to submit a CDM RE project, but no significant effect on the amount of CDM RE investment. The first result may be an indication that CDM investment is regarded as some kind of substitute to FDI, so that countries with low FDI inflows are those more likely to engage in the CDM (within the renewable energy sector) at all. The insignificant result in the positive part of the models may be related to the fixed effects specification, or to fact that we do not differentiate between unilateral and bilateral CDM projects: Flues (2010) finds that FDI matters for bilateral CDM projects that rely on foreign investments, but not for unilateral ones. Trade openness seems to have a positive effect on the amount of CDM RE investment, as expected, but no effect on initial CDM investment; the observed effect is again only visible in the fixed effects specifications.

Among the variables measuring domestic institutions – political stability, government effectiveness and democracy –, we only find consistently positive effects (of democracy and government effectiveness) on the initial decision to invest in RE CDM projects. No effect is apparent on the amount of CDM investment, which probably hinges again on the fixed effects model being used. In addition, the governance variables are quite highly correlated with each other, with GDP per capita and with years of schooling. Countries with good education and high income levels tend to have more effective and stable governments; thus, after controlling for education and income governance seems to have little (if at all) importance for CDM investment.

The socioeconomic variables – years of schooling, total GDP, GDP per capita, capital formation and GDP growth – are clearly relevant for the decision to invest in renewable energy through the CDM. This is consistent with previous studies looking more generally at total CDM investment (e.g. Flues 2010). More educated, larger economies with higher availability of domestic capital are more likely to be among the ones proposing CDM projects that deploy renewable energy. However, the relevance of these variables for the amount of CDM projects supporting renewables cannot be clearly established with our data: while schooling does not seem to be relevant, the size of the economy is positively related to CDM investment in the pooled specifications of Table 6.4, and negatively related in the fixed effects IV specification; capital formation displays a weak positive effect only in one specification. Again, this is likely a result of the fixed effects model. More interesting is the role of per capita income: we find an apparently not very intuitive negative effect of income on the likelihood that a country proposes a renewable energy CDM project at all, but a positive effect on the amount of CDM projects supporting renewables, particularly in the fixed effects specification. The first effect can be explained through the substantial amount of quite rich countries that do not participate in the CDM, such as some oil-producing states and several small island states (e.g. Bahamas, Bahrain, Barbados, Kuwait, Qatar, St. Lucia, among others). The second effect implies that, once a country starts using the CDM to support RE projects, a higher per capita income leads to a larger amount of CDM projects in this area – richer countries tend to profit more from the

variable work at all in the binary regressions. Specifications omitting this variable were also tried out, and in general they showed a stronger effect of the policies variable on RE CDM. As the DNA variable appears to be very relevant in the regressions, we opted for presenting the (more conservative) results including it.

CDM. Finally, for GDP growth we do not find any significant effect in the selection equations, but we find that, after controlling for total GDP and GDP per capita, growth negatively affects the amount of renewable energy CDM project development.

The imports of electricity, gas and coal (our measure for energy insecurity), as well as the other energy-related variables (emissions from electricity and heat, and fossil fuel production per GDP), do not seem to matter for either the likelihood to host RE CDM projects or the amount of such projects in the country. There is a negative and weakly significant effect of emissions in the selection equation of the Heckman model, but this effect disappears in the other specifications and its direction is against our expectations.

Finally, a country's surface area – our very general proxy for renewable energy potential – never has the expected positive effect on RE CDM investment. We even find a statistically significant negative effect in the fixed effects models for the outcome equation (Table 6.3), which we believe is related to corrections in several countries' reported surface area, which may correlate spuriously with changes in CDM investment over time.

In summary, it appears that, besides supporting policies for renewable energy and CDM-specific institutions or knowledge, only very general economic characteristics, as well as being a democracy, matter for hosting RE CDM projects.

<u>Results: Individual RE energy technologies in the dependent variable</u>

Table 6.5 displays the results when regressing our RE support policies variable on the amount of power from individual renewable energy technologies deployed through the CDM: wind, biomass, small hydro and solar photovoltaic. In these cases, no instrumental variable models are presented, as the instruments were not found to be strong enough. We are however quite certain, at least in the outcome equations, that the *RE support policies* variable is exogenous. In the selection equation this is not so clear, and hence the validity of these results may be reduced due to the endogeneity concern. Another caveat of these results is the significantly reduced number of observations in the outcome equations: when pooling all RE technologies together, we had 208 country-year observations that had submitted RE CDM projects for validation. In the case of individual technologies, we have for wind only 68 observations, for biomass 101, and for hydro and solar 116 observations, respectively. Inferences are hence much weaker in these regressions. To improve our degrees of freedom we thus exclude some variables from the outcome equations: fossil fuel production, DNA, political stability and emissions from electricity and heat. These variables were never found to be significant in the models shown on Table 6.4; additionally, the Wald test indicated that they were jointly not relevant for the regressions in Table 6.5. As discussed above, we do not have a theoretical expectation that having a DNA is relevant for the amount of CDM investment; political stability is quite highly correlated with government effectiveness and income, so its effect is likely already accounted for through these variables. In addition, the year dummies are excluded whenever none of them has a significant effect in the regression and a Wald test shows that they are not jointly significant either.

Table 6.5: Regression results for individual renewable energy technologies

MODEL	Wind: Panel two-part model		Biomass: Panel two-part model		Small hydro: Panel two-part model		Photovoltaic: Panel two-part model	
	RE probit	FE linear, clustered	RE probit	FE linear, clustered	RE probit	FE linear, clustered	RE probit	FE linear, clustered
VARIABLES	Selection equation	Outcome equation	Selection equation	Outcome equation	Selection equation	Outcome equation	Selection equation	Outcome equation
RE support policies (lag)	0.272 (0.101) ***	0.285 (0.127) **	0.25 (0.085) ***	0.059 (0.137)	0.067 (0.099)	0.202 (0.179)	0.105 (0.101)	0.365 (0.150) **
Fossil fuel production per GDP	-2102 (1204) *		-498.3 (909.1)		-412.3 (768.1)		-442.1 (895.3)	
Member in the CDM EB	0.115 (0.345)	2.108 (1.481)	-0.011 (0.341)	0.335 (0.500)	-0.337 (0.346)	-0.0373 (0.424)	-0.27 (0.351)	0.228 (0.615)
DNA established	0.547 (0.435)		1.413 (0.505) ***		0.339 (0.402)		0.499 (0.384)	
FDI inflows	0.0257 (0.031)	-0.0447 (0.079)	-0.0813 (0.039) **	0.275 (0.169)	-0.0038 (0.032)	0.0599 (0.094)	-0.0128 (0.0301)	-0.0724 (0.084)
Total trade	-0.00421 (0.004)	0.0174 (0.017)	0.00847 (0.003) ***	-0.0125 (0.015)	-0.0080 (0.005)	0.0103 (0.020)	-0.00785 (0.005)	0.00376 (0.034)
Political stability	0.249 (0.211)		-0.0188 (0.205)		0.223 (0.278)		-0.0714 (0.273)	
Government effectiveness	-0.0706 (0.365)	1.316 (2.220)	0.0366 (0.327)	-0.741 (1.935)	0.125 (0.398)	-0.757 (1.510)	0.47 (0.427)	-0.514 (1.711)
Democracy	0.0509 (0.063)	0.0244 (0.151)	0.21 (0.064) ***	0.1 (0.105)	0.0912 (0.084)	-0.0408 (0.113)	0.137 (0.082) *	0.284 (0.214)
Mean years of schooling	0.00162 (0.099)	-0.0127 (0.799)	-0.0039 (0.083)	0.211 (0.450)	0.205 (0.129)	0.146 (0.479)	0.128 (0.129)	-0.0149 (0.353)
Total GDP (log, PPP)	0.489 (0.142) ***	-13.12 (7.627) *	0.52 (0.145) ***	-24.81 (8.991) ***	0.547 (0.154) ***	-11.28 (5.461) **	0.611 (0.165) ***	-17.84 (6.348) ***
GDP per capita (log, PPP)	0.182 (0.288)	18.1 (8.836) *	-0.345 (0.256)	29.28 (8.946) ***	-0.53 (0.320) *	19.14 (7.896) **	-0.669 (0.327) **	25.6 (9.804) **
Capital formation	0.039 (0.024)	0.0908 (0.101)	0.0105 (0.023)	-0.105 (0.043) **	0.084 (0.025) ***	-0.159 (0.066) **	0.0969 (0.025) ***	-0.0391 (0.180)
Gas, coal, electricity imports / GDP	-4197 (4806)	-70300 (55228)	-1757 (4027)	43871 (23315) *	5331 (5412)	-81700 (51221)	-4339 (4802)	157629 (110753)
Wind speed	0.0162 (0.011)							
Agricultural area			5.2E-07 (2.4e-06)	-5.5E-06 (5.1e-05)				
Precipitation					0.0011 (0.0003) ***			
Altitudinal difference					0.0003 (0.0001) ***			
Latitude tilt radiation							-1.067 (0.374) ***	
Emissions from electricity and heat	0.00017 (0.001)		-2.8E-05 (0.0005)		-0.0003 (0.0007)		-0.00082 (0.0007)	
GDP growth	0.00335 (0.041)	-0.0319 (0.054)	0.0378 (0.039)	-0.071 (0.056)	-0.123 (0.040) ***	0.0322 (0.034)	-0.158 (0.041) ***	-0.0905 (0.068)
Observations	887	68	926	101	926	116	887	116
Number of countries	117	27	123	38	123	36	117	36
Year fixed effects	YES	NO	YES	YES	YES	NO	YES	NO

Note: Standard errors in parentheses. Levels of significance are: *** 0.01; ** 0.05; * 0.10. In the selection equations, the dependent variable is a dummy indicating whether the country has submitted a renewable energy CDM project for validation. In the outcome equations, the dependent variable is the natural logarithm of renewable energy capacity using the respective technology of CDM projects submitted for validation. Constants not reported.

Despite these caveats, the results allow us to find details that were not possible to distinguish in the specifications with all RE projects together. When looking at the coefficient on the *RE support policies* variable, it is always positive, but only in some instances statistically significant. For wind energy, supportive policies seem to matter both for the decision to submit a first project to the CDM (selection equation) and for the amount of electricity to be deployed through the CDM (outcome equation), which is in line with the main hypothesis in this chapter: Wind power is a technology that is relatively new in many developing countries and not yet competitive with traditional, often subsidized thermal power plants. While the CDM may certainly help to make it more competitive, the existence of supportive policies and measures in the host country makes more deployment possible. The results for biomass power are somewhat different. In this case, *RE support policies* seem to be relevant only for the decision to submit a first project to the CDM, but not for the size of the CDM project portfolio. There may be several reasons for this. Supportive policies are not always applicable to all RE technologies. Several countries, for example, have FITs for solar and for wind energy, but not for biomass. Biomass projects also have a different financial structure than other renewable energies, as they depend on the availability and the cost of the biomass fuel. It is likely that it is rather the availability of fuel that determines the potential for these projects, and our control variable for this availability – *agricultural area* - is not capturing this dimension well enough. For small hydro power, the *RE support policies* variable is neither in the selection equation nor in the outcome equation significant; in this case only socio-economic variables and hydrological potential seem to matter. Finally, *RE support policies* matter for the amount of photovoltaic power to be deployed through the CDM, but not for being one of the countries involved in such projects at all.

These findings are interesting. Photovoltaic is the most expensive renewable energy technology among those analysed in this study. The CDM subsidy is clearly not sufficient to overcome its financing gap. Our statistical results indicate that domestic support policies, by for example reducing the taxes or providing affordable loans for such projects, or by setting a higher electricity tariff for (specific types of) renewables, are a relevant enabling factor for the development of these particularly expensive renewable energy projects under the CDM. The second technology for which supportive policies are relevant in terms of amount of energy capacity deployed, wind energy, is more mature and no longer so expensive. Still, it is linked to technologies that are not known in many developing countries, and to an intermittent resource that makes its use more challenging. Hydro power is probably the other extreme. It is a mature technology, well known in many developing countries. More challenging are small hydro projects, particularly those that do not involve constructing a dam, due to the reduced economies of scale and the less secure hydrological resource. Still, they are more likely closer to profitability than other RE technologies, and hence supportive instruments do not seem so necessary. Biomass power is a more complex case. On the one hand, the thermal technology used to burn biomass for energy is similar to other thermal combustion technologies, and hence well known worldwide, so it can be argued that barriers to its use are relatively low. But the technology needs to be adapted to the new fuel type(s), and has also been improved to increase efficiency, allow cogeneration of heat and power, and allow co-firing of traditional fossil fuels with biomass. In addition, biomass CDM projects are typically located wherever the necessary fuel is abundant: sugar industries with bagasse as a by-product, oil palm plantations and processing plants, large animal farms with manure that can be composted into biogas (REN21 2012). It may well be that it is the presence of these industries, which we cannot control for in detail with our variables, that is most important for the location of these projects, rather than the existence of supportive policy frameworks.

With respect to the control variables, we can identify several patterns across all technologies. CDM knowledge and institutions appear to be of little relevance. Having a national authority for the CDM (DNA) seems to matter only for having biomass projects, probably because this is a relatively easily accessible technology, promoted strongly by international CDM project developers sourcing projects all over the world, so that countries starting to venture into the CDM do so by proposing biomass projects rather than other project types. In terms of ties with industrialized countries, these again seem to be relevant only for biomass projects. This seems consistent with the idea that biomass projects are pursued very commonly bilaterally, with strong presence of international project developers and investors. In this case, firms in host countries that are more open to international trade have more international ties and are more likely to enter into such joint ventures first. The negative sign in the FDI variable may be related to the fact that this variable measures net FDI flows, and hence it may be negative for countries that invest heavily in other countries themselves. Among the more general institutional variables, democracy is the only variable with a discernable effect: all else equal, more democratic countries are more likely to develop biomass and photovoltaic power projects.

As in the more general equations in Tables 6.3 and 6.4, the socioeconomic variables are clearly the most robust. Total GDP has a consistently positive and significant effect in the selection equation – larger economies are the ones most likely to engage in CDM projects involving renewable energy at all. But once a country belongs to this group, it is per capita income the relevant variable that affects how much renewable energy is deployed in each of the technologies analysed. Total GDP even has a negative effect on the amount of renewable energy deployed. As we are using country fixed effects, this is not so surprising. With fixed effects, it is not the difference in total GDP between China or India and e.g. Vietnam that matters for the regression results, but the evolution of GDP (or GDP per capita) within each country from 2003 to 2010. In this case, income per capita seems to be a better indicator of the economic power of the country than total GDP. This was also corroborated in robustness checks excluding either of the two variables, where we found that the positive effect of GDP per capita is more robust than the negative effect of total GDP. A similar phenomenon may explain the negative sign for capital formation in some of the outcome equations (bearing in mind that it has a positive and significant effect in several of the selection equations).

The energy-related variables are little relevant. We only observe a weakly significant and negative effect of fossil fuel production for the selection into wind CDM projects (this could be explained through a strong fossil fuel lobby that opposes renewable energy development), and a positive effect of gas, coal and electricity imports (energy insecurity) on the amount of biomass energy to be deployed through the CDM. The importance of having good renewable energy resources is also limited. More precipitation and altitudinal difference seem to increase the likelihood of having hydro power projects at all; as these variables are time-invariant, they are excluded from the fixed effects outcome equation. Solar radiation has an effect opposite to our expectation: it seems to decrease the likelihood of having photovoltaic projects. It is probably technological and financial capacity rather than natural resources that are important for venturing into expensive photovoltaic projects.

All in all, hence, Table 6.5 provides further evidence in support of this chapter's hypothesis: that domestic renewable energy support policies complement the CDM subsidy in facilitating the deployment of RE technologies, in particular the most expensive or technologically challenging among them: photovoltaic and wind energy. It also emphasizes the findings in Tables 6.3 and 6.4 that beyond support policies, mostly socioeconomic factors are relevant for renewable energy development under the CDM.

6.6 Conclusions

This chapter discusses and attempts to find empirical evidence for the idea that national-level renewable energy support policies may positively affect the investments in renewable energy capacity through the Clean Development Mechanism. This hypothesis is tested on a dataset of CDM investments in renewable electricity in developing countries, using the amount of RE support policies adopted in the country as main explanatory variable, while controlling for several other country characteristics that, according to the existing literature, may affect RE deployment or CDM investment. Panel two-part and pooled Heckman selection models were used, as well as instrumental variable two-part specifications to control for the concern about endogeneity of the policies variable.

The results provide first evidence for such effect. In the models analysing the effect of support policies on the aggregate CDM RE deployment we find a consistently significant and positive effect of such policies, both in the selection equations modelling the likelihood that RE projects are submitted to the CDM at all, and in the outcome equations modelling the amount of RE energy capacity to be deployed through the CDM. The results are somewhat weaker in some IV specifications due to the relatively weak instruments used, but still positive and in several cases significant.

When looking at specific renewable energy technologies, a more differentiated picture becomes evident. RE support policies seem to be relevant for the deployment of those technologies that are more expensive or technologically less known (photovoltaic and wind power), but not for those technologies that are already being used in developing countries (hydro power) or are strongly dependent on specific industries for their development (biomass power). The barriers to the deployment of RE power appear to be different for different technologies, so that different supporting mechanisms may also be needed.

These results, while still exploratory, open ground for further research. It would be interesting to look in more detail at each RE technology, and in particular at the specific effect of each of the different support policies. For such purpose, more detailed data would need to be collected on the types of supportive policies in place, their importance in terms of the size of the financial incentive provided, and also on other general controls, such as electricity prices in developing countries. Such research would be an interesting contribution to the public policy, environmental policy and environmental economics literature in developing countries, and, from the aspect of the interaction between domestic-level and international climate policies, to the literature on multi-level governance.

These results are also relevant for climate policy practitioners. In the current debate over climate and energy policies, the relationship between national-level policies and the international regime is rapidly gaining in importance. Policy-makers are looking for international and national solutions to the climate change threat, and renewable energy is one of the options that may bring considerable co-benefits for the climate and for domestic policy goals. They are also looking for possible sources of finance for climate change mitigation. The possibility to complement expensive domestic support mechanisms with international support through carbon markets may make governments in developing countries more willing to adopt such support mechanisms. On the other hand, concerns about the additionality of carbon credits in the market, if they are profiting from domestic financial support, are likely to continue. Developing countries may regard such an arrangement as a subsidy from the South towards compliance with emission reduction targets in the North. Industrialized countries may believe that the projects they are acquiring carbon credits from may not be additional to business as usual, because the financial support from the host government would have made them happen anyway. In a world in which climate change objectives are clearly intertwined with energy security and competitiveness concerns by both Northern and Southern countries, it is naïve to expect pure climate change goals. Compromise between these concerns is surely needed, and a better understanding, through research, of how such combinations of domestic and international regimes might work, can be helpful towards that goal.

6.7 Appendix 6A: Variables and descriptive statistics

Table 6A.1: Descriptive statistics, original and imputed dataset

Variable	Original dataset			Imputed dataset			Description
	Obs.	Mean	Std. Dev.	Obs.	Mean	Std. Dev.	
lnrenewables	1170	1.8129	3.5667	1170	1.8129	3.5667	Natural log of capacity of renewable energy CDM projects submitted for validation (tens of kW, zeros added)
lnwind	1170	0.3971	1.4211	1170	0.3971	1.4211	Natural log of capacity of wind energy CDM projects submitted for validation (MW, zeros added)
lnbiomass	1170	0.5643	1.7985	1170	0.5643	1.7985	Natural log of capacity of biomass energy CDM projects submitted for validation (hundreds of kW, zeros added)
lnhydro	1170	0.9257	2.5274	1170	0.9257	2.5274	Natural log of capacity of small hydro power CDM projects submitted for validation (tens of kW, zeros added)
lnpv	1170	0.1768	1.1924	1170	0.1768	1.1924	Natural log of capacity of photovoltaic energy CDM projects submitted for validation (tens of kW, zeros added)
drenewables	1170	0.2179	0.4130	1170	0.2179	0.4130	Country has submitted a renewable energy CDM project for validation (dummy)
dwind	1170	0.0838	0.2771	1170	0.0838	0.2771	Country has submitted a wind energy CDM project for validation (dummy)
dbiomass	1170	0.0983	0.2978	1170	0.0983	0.2978	Country has submitted a biomass energy CDM project for validation (dummy)
dhydro	1170	0.1239	0.3296	1170	0.1239	0.3296	Country has submitted a small hydro power CDM project for validation (dummy)
dpv	1170	0.1239	0.3296	1170	0.1239	0.3296	Country has submitted a photovoltaic energy CDM project for validation (dummy)
RE support policies (lag)	1170	0.5822	1.3303	1170	0.5822	1.3303	Count of renewable energy support policies in the country (manually imputed, lagged 1 year)
Fossil fuel production per GDP	785	0.0003	0.0004	1124	0.0008	0.0026	Fossil fuel production / GDP (toe / constant 2005 international $)
Member in the CDM EB	1170	0.0999	0.3023	1170	0.0999	0.3023	Country has a full or alternate member in the CDM EB (dummy)
DNA established	1168	0.6387	0.4806	1168	0.6387	0.4806	Country has a Designated National Authority for the CDM (dummy)
FDI inflows	1133	5.3188	6.9796	1161	5.2907	6.9280	Foreign direct investment, net inflows (% of GDP)
Total trade	1081	90.221	46.675	1145	89.430	46.194	Trade (% of GDP)
Political stability	1167	-0.3700	0.8783	1167	-0.3700	0.8783	WGI Political Stability and Lack of Violence estimate (higher is better)
Government effectiveness	1168	-0.3693	0.7531	1168	-0.3693	0.7531	WGI Government Effectiveness estimate (higher is better)
Democracy	902	5.5933	2.9846	1039	5.5898	2.9931	Democracy (Freedom House/Imputed Polity)
Mean years of schooling	744	6.4250	2.6485	1168	6.4130	2.6937	Mean years of schooling (adults aged 25 and above, years)
Total GDP (log, PPP)	1114	24.071	1.8711	1157	24.076	1.8540	Natural log of GDP PPP (constant 2005 international $)
GDP per capita (log, PPP)	1114	8.3036	1.1632	1157	8.3097	1.1549	Natural log of GDP per capita PPP (constant 2005 international $)

Variable	Original dataset			Imputed dataset			Description
	Obs.	Mean	Std. Dev.	Obs.	Mean	Std. Dev.	
Capital formation	1027	22.682	7.9198	1027	22.682	7.9198	Gross fixed capital formation (% of GDP)
Gas, coal, electricity imports / GDP	1055	0.00001	0.00004	1104	0.0000	0.0000	Imports of gas, coal and electricity per GDP (toe/cons 2005 intl $)
Surface area (log)	1170	11.681	2.2532	1170	11.681	2.2532	Natural log of surface area of the country (square km)
Wind speed	1107	19.277	14.414	1107	19.277	14.414	% of time wind speed at 50m over surface is above 6m/s (average for country)
Agricultural area	1164	24448	58828	1170	24325	58701	Agricultural area (1000 Ha)
Precipitation	1170	1216.2	842.4	1170	1216.2	842.4	Average annual precipitation in the country (mm)
Altitudinal difference	1170	2820.5	2164.5	1170	2820.5	2164.5	Altitudinal difference in the country (m)
Latitude tilt radiation	1107	5.3829	0.6214	1107	5.3829	0.6214	Average latitude tilt radiation (kWh/m2/day) in the country
Emissions from electricity and heat	552	491.19	312.14	1039	492.29	316.59	CO_2 emissions per kWh of electricity and heat generation (grams CO_2/kWh)
GDP growth	1132	5.1266	5.0836	1158	5.1168	5.0797	GDP growth (annual %)
International NGOs (lag)	1170	1432.0	1085.8	1170	1432.0	1085.8	Number of international NGOs with members in the country (lagged 1 year)
Environmental NGOs (lag)	1016	5.6575	7.5199	1016	5.6575	7.5199	Number of environmental NGOs active in the country (lagged 1 year)
Water access (lag)	1105	81.414	17.037	1170	81.511	17.057	Improved water source (% of population with access) (lagged 1 year)
Particulates (lag)	992	54.508	34.229	1169	53.212	34.316	PM10, country level (micrograms per cubic meter) (lagged 1 year)

Table 6A.2: Correlation table, imputed dataset

VARIABLE	lnrenewables	lnwind	lnbiomass	lnhydro	lnpv	RE support policies (lag)	Fossil fuel prod./GDP	Member in the CDM EB	DNA established	FDI inflows
lnrenewables	1									
lnwind	0.6325	1								
lnbiomass	0.707	0.4334	1							
lnhydro	0.7384	0.4309	0.5453	1						
lnpv	0.2915	0.3238	0.1945	0.2073	1					
RE support policies (lag)	0.604	0.6023	0.5633	0.4721	0.3838	1				
Fossil fuel production per GDP	-0.1297	-0.0668	-0.0816	-0.0907	-0.0339	-0.1087	1			
Member in the CDM EB	0.207	0.2639	0.271	0.2412	0.0512	0.2608	-0.0701	1		
DNA established	0.3581	0.1824	0.2502	0.2548	0.1045	0.2566	-0.1694	0.1194	1	
FDI inflows	-0.0956	-0.057	-0.0906	-0.0602	-0.0633	-0.107	0.098	-0.0329	0.0021	1
Total trade	-0.0963	-0.1257	-0.0666	-0.1147	-0.0119	-0.1405	0.0256	-0.1327	-0.0526	0.3845
Political stability	-0.0461	-0.0034	-0.0377	-0.0688	-0.0089	-0.0624	-0.011	-0.0056	0.0115	0.0994
Government effectiveness	0.2587	0.181	0.1931	0.1413	0.1584	0.2261	-0.1773	0.1593	0.1779	0.0602
Democracy	0.2638	0.1274	0.1935	0.1784	0.0817	0.2294	-0.0612	0.118	0.158	-0.0137
Mean years of schooling	0.1869	0.0904	0.0659	0.1112	0.0845	0.156	-0.1165	0.1028	0.1532	0.1441
Total GDP (log, PPP)	0.5234	0.4383	0.4538	0.421	0.2478	0.5307	-0.2666	0.2894	0.2342	-0.1971
GDP per capita (log, PPP)	0.1674	0.1231	0.1041	0.0832	0.1122	0.1561	-0.1261	0.0705	0.1177	0.0528
Capital formation	0.1646	0.1718	0.1243	0.1913	0.1229	0.165	-0.0643	0.1383	0.1571	0.2892
Gas, coal, electricity imports / GDP	0.0702	0.0351	0.0274	0.0476	0.1052	0.0852	-0.0679	0.1272	0.0351	0.1272
Surface area (log)	0.2485	0.2242	0.261	0.2316	0.0549	0.2399	-0.1017	0.1667	0.0471	-0.1922
Emissions from electricity and heat	-0.019	0.0647	0.0203	-0.0421	0.0806	0.0483	0.0256	0.0182	-0.0276	0.0474
GDP growth	-0.005	0.0462	0.0185	-0.0045	0.0015	-0.0118	-0.0182	0.0168	-0.0101	0.0197
Wind speed	-0.0766	0.0285	-0.1001	-0.1105	-0.0191	-0.0007	-0.0659	0.1304	0.0476	0.0797
Agricultural area	0.3523	0.526	0.4174	0.3633	0.1601	0.4438	-0.0561	0.4146	0.036	-0.0697
Precipitation	0.1699	-0.0354	0.149	0.1901	-0.02	0.0483	0.0949	0.0122	0.1399	0.0051
Altitudinal difference	0.3285	0.2668	0.2596	0.3398	0.0538	0.3036	-0.1056	0.1833	0.1572	-0.131
Latitude tilt radiation	-0.1632	-0.0344	-0.1261	-0.2215	-0.0687	-0.1055	0.0111	-0.0379	-0.0929	-0.1292
International NGOs (lag)	0.6226	0.4944	0.5496	0.4436	0.2256	0.6259	-0.1962	0.3385	0.2764	-0.1547
Environmental NGOs (lag)	0.318	0.2516	0.3016	0.2485	0.0067	0.3566	-0.1204	0.2846	0.1201	-0.0858
Water access (lag)	0.246	0.1586	0.1732	0.1726	0.0977	0.227	-0.1201	0.1114	0.2111	0.0218

Correlation table (continued)

VARIABLE	Total trade	Political stability	Government effectiveness	Democracy	Mean years of schooling	Total GDP (log, PPP)	GDP/cap (log, PPP)	Capital formation	Gas, coal, electricity imports/GDP	Surface area (log)
Total trade	1									
Political stability	0.3446	1								
Government effectiveness	0.3167	0.5313	1							
Democracy	-0.0266	0.2297	0.4304	1						
Mean years of schooling	0.2535	0.3197	0.5067	0.2609	1					
Total GDP (log, PPP)	-0.1429	-0.1421	0.3332	-0.0105	0.2216	1				
GDP per capita (log, PPP)	0.3051	0.4973	0.678	0.1573	0.6441	0.4066	1			
Capital formation	0.1598	0.2139	0.1549	-0.0656	0.0833	0.1059	0.1564	1		
Gas, coal, electricity imports / GDP	0.1189	-0.0392	0.0834	0.0451	0.2953	0.0281	0.046	0	1	
Surface area (log)	-0.4179	-0.3777	-0.3432	-0.1605	-0.2487	0.4768	-0.31	0.0292	-0.0983	1
Emissions from electricity and heat	0.0751	0.1981	0.2077	-0.0703	0.1362	0.1274	0.3235	0.1094	0.0297	-0.1531
GDP growth	0.0308	0.015	-0.0572	-0.1441	-0.0391	0.1109	0.0314	0.2789	-0.0212	0.1007
Wind speed	-0.0154	0.1987	0.2257	0.0517	0.2972	-0.0139	0.222	0.079	0.1446	-0.1733
Agricultural area	-0.2068	-0.0901	0.0253	-0.0517	-0.008	0.5219	0.0211	0.1871	-0.0547	0.5317
Precipitation	0.1562	-0.0191	0.013	0.3211	-0.0415	-0.0874	-0.0774	-0.0482	-0.1536	-0.1558
Altitudinal difference	-0.286	-0.3666	-0.1169	-0.0369	-0.0061	0.3291	-0.1947	0.1196	0.0067	0.4523
Latitude tilt radiation	-0.1903	0.0249	0.0421	-0.0374	-0.3014	-0.0774	-0.0779	-0.1798	-0.2531	0.0322
International NGOs (lag)	-0.1565	-0.0948	0.4433	0.3741	0.2329	0.7769	0.2844	-0.037	0.0533	0.3463
Environmental NGOs (lag)	-0.2095	-0.0433	0.1547	0.2624	0.2894	0.3712	0.1565	-0.0303	0.16	0.2751
Water access (lag)	0.1323	0.306	0.5882	0.3081	0.6164	0.254	0.6481	0.0898	0.1627	-0.384

Correlation table (continued)

VARIABLE	Emissions from electricity and heat	GDP growth	Wind speed	Agricultural area	Precipitation	Altitudinal difference	Latitude tilt radiation	International NGOs (lag)	Environmental NGOs (lag)	Water access (lag)
Emissions from electricity and heat	1									
GDP growth	-0.0299	1								
Wind speed	0.0652	0.0429	1							
Agricultural area	0.0705	0.1129	0.0501	1						
Precipitation	-0.2159	-0.0657	-0.3708	-0.1705	1					
Altitudinal difference	-0.2544	0.1342	0.0058	0.3575	0.0212	1				
Latitude tilt radiation	0.1872	-0.1177	0.3502	0.0582	-0.3999	-0.1721	1			
International NGOs (lag)	0.0147	-0.0681	-0.0812	0.4698	0.0793	0.3239	-0.0652	1		
Environmental NGOs (lag)	-0.0866	0.0083	0.079	0.4107	-0.0591	0.4655	-0.1805	0.5475	1	
Water access (lag)	0.2058	-0.1321	0.171	-0.064	0.0225	-0.0756	-0.2168	0.3305	0.2791	1

6.8 Appendix 6B: First stage regressions for the IV specifications

Table 6B.1: First stage regressions for the IV regressions in Table 6.3 (selection equations)

MODEL VARIABLES	(4 first) Rivers-Vuong IV with RE probit normal errors			(5 first) MLE pooled IV probit clustered errors			(6 first) Rivers-Vuong IV with RE probit normal errors			(7 first) MLE pooled IV probit clustered errors	
Fossil fuel production per GDP	6.791	(10.29)		0.507	(6.112)		10.9066	(11.027)		4.787	(7.728)
Member in the CDM EB	-0.0511	(0.097)		-0.19	(0.179)		-0.0174	(0.1008)		-0.192	(0.198)
DNA established	-0.118	(0.075)		-0.0909	(0.083)		-0.0930	(0.0790)		-0.0751	(0.087)
FDI inflows	-0.00286	(0.005)		-0.00246	(0.005)		-0.0024	(0.0056)		-0.00317	(0.005)
Total trade	-0.000801	(0.001)		-0.000589	(0.002)		-0.0007	(0.0013)		0.000392	(0.003)
Political stability	0.00807	(0.076)		-0.106	(0.113)		-0.0409	(0.0804)		-0.144	(0.132)
Government effectiveness	-0.328	(0.118)	***	-0.399	(0.196)	**	-0.0340	(0.1203)		-0.215	(0.233)
Democracy	0.000234	(0.021)		-0.0176	(0.032)		0.0423	(0.0214)	*	-0.0021	(0.036)
Mean years of schooling	-0.0104	(0.026)		-0.00468	(0.032)		-0.0124	(0.0271)		-0.00257	(0.037)
Total GDP (log, PPP)	0.00536	(0.070)		0.114	(0.164)		0.3208	(0.0632)	***	0.148	(0.225)
GDP per capita (log, PPP)	0.073	(0.098)		0.48	(0.347)		-0.0331	(0.1021)		0.668	(0.486)
Capital formation	0.013	(0.005)	**	0.00684	(0.005)		0.0091	(0.0055)	*	0.00729	(0.006)
Gas, coal, electricity imports / GDP	1979	(1357)		2510	(2195)		2578.83	(1397.3)	*	4419	(3037)
Surface area (log)	-0.0602	(0.048)		-5.222	(6.089)		-0.0283	(0.0525)		-4.924	(5.913)
Emissions from electricity and heat	0.000218	(0.000)		0.000154	(0.000)		0.0002	(0.0002)		0.000139	(0.000)
GDP growth	0.00222	(0.006)		0.00252	(0.004)		-0.0034	(0.0060)		-0.00247	(0.005)
Water access (lag)	-0.00151	(0.006)		-0.0282	(0.020)		0.0017	(0.0061)		-0.036	(0.026)
International NGOs (lag)	0.000877	(0.000)	***	0.00339	(0.002)	**					
Environmental NGOs (lag)							0.0215	(0.0100)	**	-0.0379	(0.033)
Observations	926			905			906			885	
Number of countries	123			120			120			117	
Year fixed effects	YES			YES			YES			YES	
Controls for country means	NO			YES			NO			YES	

Note: Standard errors in parentheses. Levels of significance are: *** 0.01; ** 0.05; * 0.10. The dependent variable is *RE support policies*. Constants not reported.

Table 6B.2: First stage regressions for the IV regression in Table 6.4 (outcome equations)

MODEL VARIABLES	(12 first) IV FE G2SLS first stage normal errors		
Fossil fuel production per GDP	-1808	(5072)	
Member in the CDM EB	-0.637	(0.375)	*
DNA established	0.493	(0.523)	
FDI inflows	0.0481	(0.055)	
Total trade	-0.0178	(0.013)	
Political stability	-0.423	(0.579)	
Government effectiveness	-0.19	(1.029)	
Democracy	-0.0703	(0.103)	
Mean years of schooling	-0.179	(0.329)	
Total GDP (log, PPP)	15.94	(9.169)	*
GDP per capita (log, PPP)	-8.254	(9.007)	
Capital formation	-0.0413	(0.0512)	
Imports of gas, coal, electricity / GDP	-70923	(31950)	**
Surface area (log)	845.4	(484.8)	*
Emissions from electricity and heat	-0.000323	(0.001)	
GDP growth	0.0144	(0.040)	
International NGOs (lag)	0.00465	(0.003)	
Particulates (lag)	0.0474	(0.024)	**
Observations	208		
Number of countries	61		
Year fixed effects	YES		
Controls for country means	NO		

Note: Standard errors in parentheses. Levels of significance are: *** 0.01; ** 0.05; * 0.10. The dependent variable is *RE support policies*. Constants not reported.

7. CONCLUDING REMARKS

In this dissertation I analyse the potential effects of the CDM and some of its reform proposals on climate change mitigation in the South. I start from the assumptions that the CDM may provide positive incentives towards climate change mitigation in developing countries if it is successful in incentivizing (1) investment in low-carbon technologies in LDCs, (2) a transition towards non-offset mitigation instruments in advanced developing countries, and (3) investment in non-mature low-carbon technologies.

The theoretical framework presented in Chapter 2 shows that the CDM can have both positive and negative incentives on mitigation in developing countries. Five negative incentives were identified, which may affect the amount of emission reductions achieved through the CDM itself, the potential mitigation through domestic climate-friendly policies in developing countries, and the willingness of CDM host countries to adopt future emission reduction targets. Two positive incentives for mitigation were found: the first one is the potential of the CDM to capitalize on the window of opportunity in LDCs and contribute to fostering investment in clean technologies, thereby contributing to a lower long-term emissions path; the second one considers that the CDM may help expensive, immature emission reduction technologies achieve cost effectiveness earlier, by financially supporting their diffusion in developing countries.

Chapters 3 to 6 analysed empirically different aspects of how the CDM – or proposals made for its reform – may affect some of the incentive mechanisms described above. Chapters 3 and 4 looked at two measures that have been proposed for addressing the geographical distribution of the CDM. In the incentives framework developed in this dissertation, by addressing this geographical distribution and promoting more CDM projects in LDCs, the CDM can be directed towards improving the long-term emissions path of these countries. However, the empirical analysis showed that, even under quite strict preferential access or discounting schemes, LDCs cannot compete with other CDM host countries in terms of supply of CERs to the market. Hence, in practical terms, the analysis questions the ability of these two measures to achieve the goal of improving the geographical distribution of the CDM. More generally, it also questions the ability of the CDM itself to significantly address the long-term emissions path of LDCs. A future research question resulting from these conclusions is whether other instruments that have been more recently introduced in the climate change regime – for example, Nationally Appropriate Mitigation Actions (NAMAs) that are funded internationally but independently of the carbon market – may have better results supporting the low-carbon transformation of LDCs.

Chapter 5 analysed the low-hanging fruit problem, i.e., the fear of developing countries that the CDM may exhaust their cheap emission reduction opportunities and leave them with only more expensive ones to fulfil future emission reduction commitments. The empirical analysis in this chapter concluded that, so far, the CDM has not been large enough to have such an effect, and that there are still many theoretically low-cost abatement opportunities in its main host countries. These results lead to the broader conclusion that at least in terms of the low-hanging fruit problem, the CDM should not have the effect of discouraging developing countries from taking up emission reduction commitments. This conclusion is however strongly dependent on the current size and scope of the CDM. If the CDM (or similar offsetting mechanisms) is expanded significantly in the following years, the conclusion might change. Such expansion depends crucially on how demand for carbon offsets will evolve in the future, which depends on the level of ambition of future emission reduction targets and on critical technical parameters such as the consideration of supplementarity in the use of offsets (see Chapter 3). The conclusion could also change if new offsetting instruments – for example, linking the reduction of emissions from deforestation and forest degradation to the carbon market, or agreeing on sectoral crediting mechanisms – are created. In addition, this result leads to the question about why the carbon market is not yet capturing all cheap emission reduction opportunities. This would be another area for future research, as well as an analysis of whether other climate mitigation instruments (again NAMAs) might be better suited for reaching such cheap – but difficult – mitigation opportunities, and of how this would in turn affect incentives for developing countries.

Chapter 6 looked at a way in which the CDM might be successful in contributing to the diffusion of more expensive emission reduction technologies, thus inducing learning effects and cost reductions. As the carbon price is still too low for such a purpose, but I nonetheless observe expensive projects within the CDM portfolio, I hypothesize that domestic climate-friendly policies might be adding a further financial incentive to these expensive technologies, which, coupled with the CDM subsidy, makes them attractive. I thus analyse whether domestic climate-friendly policies (specifically renewable energy support policies) are helping these expensive technologies to access the CDM, and find clear evidence for such an effect: I find a statistically significant and positive effect of renewable energy support policies on aggregate CDM renewable energy investment, both in equations modelling the likelihood that renewable energy projects are submitted by a host country to the CDM at all, and in equations modelling the amount of renewable energy capacity expected to be deployed by these projects. When looking at individual renewable energy technologies separately, a more differentiated effect becomes clear: supportive policies seem to be relevant for the deployment of those technologies that are more expensive or technologically less known (photovoltaic and wind power), but not for those technologies that are already being used in developing countries (hydro power) or are strongly dependent on specific industries for their development (biomass power). The barriers to the deployment of renewable power appear to be different for different technologies, so that different supporting mechanisms may also be needed.

Future research in this area could look in more detail at the effect of each supportive policy on each particular renewable energy technology. Such research would be possible provided more accurate data on the support policies and other general characteristics of the electricity market in developing countries becomes available. Another future research area, depending also on the availability of better data, would be to look at the effect that the CDM may have had on the support policies. Such analysis would shed some light on the perverse incentive described above that the CDM may discourage the adoption of domestic climate friendly policies due to additionality concerns.

Turning back to the incentives framework described in Chapter 2, I can conclude that the CDM, in its current form, has not contributed substantially to the investment in low-carbon technologies in LDCs, as evidenced by its geographical distribution. Proposed measures to improve such geographical distribution, such as discounting the value of emission credits with differentiation across host countries, or the establishment of preferential access measures to certain demand markets, will, on their own, likely have a limited effect on such geographical distribution. Other approaches that are better suited for supporting small-scale technologies, which are arguably more in line with the needs in LDCs, such as Programmes of Activities, may have more success. In addition, support instruments that do not link emission reductions to the market, such as internationally supported NAMAs, may also be better suited for LDCs, as they may be less subject to the low-cost focus of the carbon market and to the CDM project cycle's high transaction costs.

In terms of creating incentives for a transition of advanced developing countries towards non-offset mitigation instruments, Chapter 5 shows that the "low-hanging fruit" argument does not hold yet for the CDM, meaning that this kind of negative incentive should not be in place. In broader terms, however, the theoretical framework in Chapter 2 demonstrated that there are other ways in which the CDM, with its financial transfers, may reduce the willingness of its host countries to engage in own mitigation actions.

Finally, in terms of providing support for expensive, immature low-carbon technologies, Chapter 6 provides evidence that expensive technologies are accessing the CDM, and that national policies that financially support such technologies are playing a role in allowing such investment in expensive technologies through the CDM.

REFERENCES

ADB (1998a), *Asian Least-cost Greenhouse Gas Abatement Strategy (ALGAS) Project: Republic of Korea,* Manila: Asian Development Bank.

ADB (1998b), *Asian Least-cost Greenhouse Gas Abatement Strategy (ALGAS) Project: Thailand,* Manila: Asian Development Bank.

Agyemang-Bonsu, William K. (2007), 'African Countries' Perspective of the Nairobi Framework', *SB26 Side Event Implementing the Nairobi Framework – A Mobilization Event*, 14 May 2007, Bonn: UNFCCC Secretariat, available at http://unfccc.int/meetings/sb26/side_events_and_exhibits/items/3982.php (accessed 20 April 2009).

Akita, Jiro (2003), 'A Simple Model of CDM Low-hanging Fruit', in Takamitsu Sawa (ed.), *International Frameworks and Technological Strategies to Prevent Climate Change*, London and Tokyo: Springer, pp. 66-96.

AOSIS (2011), 'Views Relating to the Establishment of One or More Market-based Mechanisms to Enhance the Cost-effectiveness Of, and to Promote, Mitigation Action As Referred to in FCCC/AWGLCA/2010/L.7', in UNFCCC Secretariat (ed.), *Views on the Elaboration of Market-based Mechanisms - Submissions From Parties, FCCC/AWGLCA/2011/MISC.2*, Bonn: UNFCCC Secretariat, pp. 40-47.

Ashworth, John, Benny Geys and Bruno Heyndels (2006), 'Determinants of Tax Innovation: The Case of Environmental Taxes in Flemish Municipalities', *European Journal of Political Economy*, **22** (1), 223-247.

Australian Government, Department of Climate Change (2008), 'Tracking to the Kyoto Target – Australia's Greenhouse Emissions Trends 1990 to 2008-2012 and 2020', Canberra: Department of Climate Change, available at http://www.climatechange.gov.au/projections (accessed 5 May 2009).

Bakker, Stefan J. A., Antonis G. Arvanitakis, Tjasa Bole, Edgar Van de Brug, Claudia E. M. Doets and Alyssa Gilbert (2007), 'Carbon Credit Supply Potential Beyond 2012, a Bottom Up Assessment of Mitigation Options', Report ECN-E--07-090, Petten: ECN - Energy Research Centre of the Netherlands, available at http://www.ecn.nl/publications/BS/2007/ECN-E--07-090.

Bakker, Stefan, Constanze Haug, Harro Van Asselt, Joyeeta Gupta and Raouf Saidi (2011), 'The Future of the CDM: Same Same, but Differentiated?', *Climate Policy*, **11** (1), 752-767.

Bakker, Stefan J. A., Harro van Asselt, Joyeeta Gupta, Constanze Haug and Raouf Saidi (2009), 'Differentiation in the CDM: Options and Impacts', Report 500102023 ECN-B—09-009, Bilthoven: Netherlands Environmental Assessment Agency, available at http://www.ecn.nl/publications/BS/2009/ECN-B--09-009.

Bang, Guri, Gorild Heggelund and Jonas Vevatne (2005), 'Shifting Strategies in the Global Climate Negotiations', CICERO Report 2005:08, Oslo and Lysaker: Center for International Climate and Environmental Research and The Fridtjof Nansen Institute.

Barker, Terry, Igor Bashmakov, Awwad Alharthi, Markus Amann, Luis Cifuentes, John Drexhage, Maosheng Duan, Ottmar Edenhofer, Brian Flannery, Michael Grubb, Monique Hoogwijk, Francis I. Ibitoye, Catrinus J. Jepma, William A. Pizer and Kenji Yamaji (2007), 'Mitigation From a Cross-sectoral Perspective', in Bert Metz, Ogunlade R. Davidson, Peter R. Bosch, Rutu Dave and Leo A. Meyer (eds.), *Climate Change 2007. Mitigation of Climate Change. Contribution of Working Group III to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change*, Cambridge and New York: Cambridge University Press, pp. 619-690.

Barrett, Scott (1990), 'The Problem of Global Environmental Protection', *Oxford Review of Economic Policy*, **6** (1), 68-79.

Baumert, Kevin A. and Nancy Kete (2002), 'Will the Kyoto Protocol Drive Industry to Developing Countries?', Earth Trends Featured Topic, Washington, D.C.: World Resources Institute, available at http://earthtrends.wri.org/pdf_library/feature/cli_fea_carbon.pdf (accessed 25 September 2009).

Baumert, Kevin A. (1999), 'Understanding Additionality', in Walter V. Reid and José Goldemberg (eds.), *Promoting Development While Limiting Greenhouse Gas Emissions: Trends and Baselines*, New York: UNDP and WRI, pp. 135-143.

Beck, Fredric and Eric Martinot (2004), 'Renewable Energy Policies and Barriers', in Cutler J. Cleveland (ed.), *Encyclopedia of Energy*, vol. 5, New York: Elsevier, pp. 365-383.

Benecke, Gudrun (2009), *Turning Wind Into Power - Effects of Stakeholder Networks on Renewable Energy Governance in India,* PhD Dissertation, University of Potsdam, Potsdam: University of Potsdam.

Berk, Marcel M. and Michel G. J. den Elzen (2001), 'Options for Differentiation of Future Commitments in Climate Policy: How to Realise Timely Participation to Meet Stringent Climate Goals?', *Climate Policy*, **1** (4), 465-480.

Bernauer, Thomas (1995), 'The Effect of International Environmental Institutions: How We Might Learn More', *International Organization*, **49** (02), 351-377.

Bénassy-Quéré, Agnés, Maylis Coupet and Thierry Mayer (2007), 'Institutional Determinants of Foreign Direct Investment', *The World Economy*, **30** (5), 764-782.

Bird, Lori, Mark Bolinger, Troy Gagliano, Ryan Wiser, Matthew Brown and Brian Parsons (2005), 'Policies and Market Factors Driving Wind Power Development in the United States', *Energy Policy*, **33** (11), 1397-1407.

Bocanegra, Javier (2009), 'Methane to Markets: PEMEX Methane Emissions Inventory and Marginal Abatement Cost Analysis', *Methane to Markets Oil & Gas Systems Technology Transfer & Subcommittee Meeting*, 16 September 2009, Lake Louise, Canada: Methane to Markets Partnership, available at www.methanetomarkets.org/documents/events_oilgas_20090914_mexicopemex_6.pdf.

Bode, Sven (2005), 'Tenders: An Option for Developing Countries to Support Renewable Energies Under the CDM', *Climate Policy*, **5** (2), 221-228.

Bode, Sven and Axel Michaelowa (2003), 'Avoiding Perverse Effects of Baseline and Investment Additionality Determination in the Case of Renewable Energy Projects', *Energy Policy*, **31** (6), 505-517.

Borges da Cunha, Kamyla, Arnaldo Walter and Fernando Rei (2007), 'CDM Implementation in Brazil's Rural and Isolated Regions: The Amazonian Case', *Climatic Change*, **84** (1), 111-129.

Brealey, Richard A. and Steward C. Myers (2000), *Principles of Corporate Finance,* Boston, MA: McGraw-Hill.

Bréchet, Thierry, Marc Germain and Vincent Van Steenberghe (2004), 'The Clean Development Mechanism Under the Kyoto Protocol and the 'low-hanging Fruits' Issue', CORE Discussion Paper 2004/81, Louvain: Université Catholique de Louvain.

Burniaux, Jean-Marc, Jean Chateau, Rob Dellink, Romain Duval and Stéphanie Jamet (2009), 'The Economics of Climate Change Mitigation: How to Build the Necessary Global Action in a Cost-effective Manner', OECD Economics Department Working Papers No. 701, Paris: OECD, available at http://ideas.repec.org/p/oec/ecoaaa/701-en.html.

Butler, Lucy and Karsten Neuhoff (2008), 'Comparison of Feed-in Tariff, Quota and Auction Mechanisms to Support Wind Power Development', *Renewable Energy*, **33** (8), 1854-1867.

Cai, Wenjia, Can Wang, Jining Chen, Ke Wang, Ying Zhang and Xuedu Lu (2008), 'Comparison of CO_2 Emission Scenarios and Mitigation Opportunities in China's Five Sectors in 2020', *Energy Policy*, **36** (3), 1181-1194.

Cameron, Adrian C. and Pravin K. Trivedi (2009), *Microeconometrics Using Stata,* College Station, TX: Stata Press.

Carley, Sanya (2009), 'State Renewable Energy Electricity Policies: An Empirical Evaluation of Effectiveness', *Energy Policy*, **37** (8), 3071-3081.

Carraro, Carlo and Domenico Siniscalco (1992), 'The International Dimension of Environmental Policy', *European Economic Review*, **36** (2-3), 379-387.

Carraro, Carlo and Domenico Siniscalco (1997), 'The International Protection of the Environment: Voluntary Agreements Among Sovereign Countries', in Partha Dasgupta, Karl-Göran Mäler and Alessandro Vercelli (eds.), *The Protection of Transnational Commons*, *WIDER studies in development economics*, Oxford: Clarendon Press.

Carter, Lisa (1997), 'Modalities for the Operationalization of Additionality', *International Workshop on Activities Implemented Jointly*, 5 March 1997, Leipzig, Germany: UNEP/BMU.

Carter, Neil (2007), *The Politics of the Environment: Ideas, Activism, Policy,* 2nd edition, Cambridge: Cambridge University Press.

Castro, Paula and Axel Michaelowa (2008), 'Empirical Analysis of Performance of CDM Projects', Climate Strategies Report, Cambridge, UK: Climate Strategies.

Castro, Paula and Axel Michaelowa (2010), 'The Impact of Discounting Emission Credits on the Competitiveness of Different CDM Host Countries', *Ecological Economics*, **70** (1), 34-42.

CDM EB (2004), 'Clarifications on the Treatment of National And/or Sectoral Policies and Regulations (paragraph 45 (e) of the CDM Modalities and Procedures) in Determining a Baseline Scenario', Annex 3 to the EB 16 Report, Bonn: UNFCCC Secretariat.

CDM EB (2009), 'Guidelines for Objective Demonstration and Assessment of Barriers (Version 01)', Annex 13 to the EB50 Report, Bonn: UNFCCC Secretariat.

CDM EB (2011), 'Report of the Sixty-first Meeting of the Executive Board of the Clean Development Mechanism, 3rd June 2011', Bonn: UNFCCC Secretariat.

CDM Methodology Panel (2008), 'Proposal for An Enhanced Barrier Test for Project Activities That Have a Potentially High Profitability Without CER Revenues', Annex 11 to the 33rd Meeting Report, Bonn: UNFCCC Secretariat.

CDM Methodology Panel (2010), 'Note on AM0001 "Incineration of HFC 23 Waste Streams"', Annex 2 to the 44th meeting report, Bonn: UNFCCC Secretariat.

Central Intelligence Agency (2010), 'The World Factbook 2010', Washington, D.C.: Central Intelligence Agency, available at https://www.cia.gov/library/publications/the-world-factbook/index.html (accessed 7 February 2011).

Chamberlain, Gary (1980), 'Analysis of Covariance with Qualitative Data', *The Review of Economic Studies*, **47** (1), 225-238.

Chamberlain, Gary (1982), 'Multivariate Regression Models for Panel Data', *Journal of Econometrics*, **18** (1), 5-46.

Chea, Chan Thou (2006), 'CDM Potential for Sustainable Development in Cambodia', *National Workshop on Integrated Capacity Strengthening for the Clean Development Mechanism (ICS-CDM) in Cambodia*, 2 March 2006, Phnom Penh, Cambodia: IGES, available at http://www.iges.or.jp/en/cdm/activity_cambodia03.html (accessed 24 April 2009).

Chung, Rae Kwon (2007), 'A CER Discounting Scheme Could Save Climate Change Regime After 2012', *Climate Policy*, **7** (2), 171-176.

Cole, John C. and J. Timmons Roberts (2011), 'Lost Opportunities? A Comparative Assessment of Social Development Elements of Six Hydroelectricity CDM Projects in Brazil and Peru', *Climate and Development*, **3** (4), 361-379.

Congleton, Roger D. (1996), 'Introduction and Overview of the Political Economy of Environmental Protection', in Roger D. Congleton (ed.), *The Political Economy of Environmental Protection: Analysis and Evidence*, Ann Arbor: The University of Michigan Press, pp. 3-28.

Cornes, Richard and Todd Sandler (1996), *The Theory of Externalities, Public Goods, and Club Goods,* 2nd edition, Cambridge, UK: Cambridge University Press.

Cosbey, Aaron (2005), 'Climate Change and Competitiveness. A Survey of the Issues', Background paper for Workshop on Climate Change, Trade and Competitiveness at Chatham House, London, 30 March 2005, Winnipeg: International Institute for Sustainable Development, available at http://www.iisd.org/pdf/2005/climate_change_comp.pdf (accessed 15 November 2011).

Cosbey, Aaron, Jo-Ellen Parry, Jodi Browne, Yuvaraj D. Babu, Preety Bhandari, John Drexhage and Deborah Murphy (2005), *Realizing the Development Dividend: Making the CDM Work for Developing Countries,* Winnipeg: International Institute for Sustainable Development.

Cosgrove, Carol (1994), 'Has the Lomé Convention Failed ACP Trade?', *Journal of International Affairs*, **48** (1), 223-249.

Crenshaw, Edward (1991), 'Foreign Investment As a Dependent Variable: Determinants of Foreign Investment and Capital Penetration in Developing Nations, 1967--1978', *Social Forces*, **69** (4), 1169-1182.

Criqui, Patrick, Silvana Mima and Laurent Viguier (1999), 'Marginal Abatement Costs of CO_2 Emission Reductions, Geographical Flexibility and Concrete Ceilings: An Assessment Using the POLES Model', *Energy Policy*, **27** (10), 585-601.

Dolšak, Nives (2001), 'Mitigating Global Climate Change: Why Are Some Countries More Committed Than Others?', *Policy Studies Journal*, **29** (3), 414-436.

Dolšak, Nives and Emily B. Crandall (2007), 'Private Sector Investments in Global Warming Mitigation: The Case of Clean Development Mechanisms', *Annual Meeting of the Western Political Science Association*, 10 March 2007, Las Vegas, NE: WPSA.

Dosi, Giovanni (1982), 'Technological Paradigms and Technological Trajectories: A Suggested Interpretation of the Determinants and Directions of Technical Change', *Research Policy*, **11** (3), 147-162.

Dunn, William N. (2004), *Public Policy Analysis: An Introduction,* Upper Saddle River, N.J.: Pearson Prentice Hall.

Dutschke, Michael and Axel Michaelowa (2006), 'Development Assistance and the CDM - How to Interpret 'financial Additionality'', *Environment and Development Economics*, **11** 235-246.

Easton, David (1965), *A Systems Analysis of Political Life,* New York, NY: John Wiley & Sons.

EEA (2005), 'Climate Change Scenarios Data', available at http://dataservice.eea.europa.eu/atlas/viewdata/viewpub.asp?id=4011 (accessed 5 May 2009).

Ellerman, A. Denny and Annelène Decaux (1998), 'Analysis of Post-Kyoto CO_2 Emissions Trading Using Marginal Abatement Curves', Report No. 40, Cambridge, MA: MIT Joint Program on the Science and Policy of Global Change.

Elliott, Euel, Barry J. Seldon and James L. Regens (1997), 'Political and Economic Determinants of Individuals' Support for Environmental Spending', *Journal of Environmental Management*, **51** (1), 15-27.

Ellis, Jane and Sami Kamel (2007), 'Overcoming Barriers to Clean Development Mechanism Projects', Report COM/ENV/EPOC/IEA/SLT(2007)3, Paris: OECD/IEA.

Enkvist, Per-Anders, Tomas Nauclér and Jerker Rosander (2007), 'A Cost Curve for Greenhouse Gas Reduction', *McKinsey Quarterly*, **1** 35-45.

Environmental Defense (2007), 'Making CDM Compatible with 2ºC', Brief for COP13/MOP3 Bali, December 3-14, 2007, available at http://www.edf.org/documents/7441_ClimateChange_CDM_1pger.pdf (accessed 15 March 2009).

ESMAP (Energy Sector Management Assistance Programme) (1999), 'Global Energy Sector Reform in Developing Countries: A Scorecard', Washington, D.C.: UNDP and the World Bank.

Europa Publications (2000), *The Environment Encyclopedia and Directory 2001,* 3rd edition, London: Routledge.

European Commission (2009), 'Commission Staff Working Document Accompanying the Communication From the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions – Towards a Comprehensive Climate Change Agreement in Copenhagen: Extensive Background Information and Analysis – Part 2', Brussels: European Commission.

European Commission (2010), 'Emissions Trading System (ETS)', Brussels: European Commission, available at http://ec.europa.eu/clima/policies/ets/index_en.htm (accessed 31 July 2011).

European Commission (2011), 'Emissions Trading: Commission Welcomes Vote to Ban Certain Industrial Gas Credits', Press Release IP/11/56, Brussels: European Commission, available at http://europa.eu/rapid/press-release_IP-11-56_en.htm (accessed 20 February 2012).

European Parliament (2009a), 'Decision No 406/2009/EC of the European Parliament and of the Council of 23 April 2009 on the Effort of Member States to Reduce Their Greenhouse Gas Emissions to Meet the Community's Greenhouse Gas Emission Reduction Commitments Up to 2020', Strasbourg: European Parliament, available at http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=CELEX:32009D0406:EN:NOT (accessed 31 July 2011).

European Parliament (2009b), 'Directive 2009/29/EC of the European Parliament and of the Council of 23 April 2009 Amending Directive 2003/87/EC So As to Improve and Extend the Greenhouse Gas Emission Allowance Trading Scheme of the Community', Strasbourg: European Parliament, available at http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=CELEX:32009L0029:EN:NOT (accessed 31 July 2011).

Fankhauser, Samuel and Snorre Kverndokk (1996), 'The Global Warming Game — Simulations of a CO_2-reduction Agreement', *Resource and Energy Economics*, **18** (1), 83 - 102.

Figueres, Christiana (2002), 'Establishing National Authorities for the CDM: A Guide for Developing Countries', Washington, D.C. and Winnipeg, Manitoba: Center for Sustainable Development in the Americas and International Institute for Sustainable Development.

Figueres, Christiana and Ken Newcombe (2007), 'Evolution of the CDM: Toward 2012 and Beyond', Discussion Paper, available at http://www.climatechangecapital.com/media/1736/evolutionofthecleandevelopmentmechanism_july2007.pdf (accessed 31 July 2011).

Flues, Florens (2010), 'Who Hosts the Clean Development Mechanism? Determinants of CDM Project Distribution', CIS Working Paper No. 53, Zurich: Center for Comparative and International Studies (CIS), ETH Zurich and University of Zurich.

Flues, Florens, Axel Michaelowa and Katharina Michaelowa (2010), 'What Determines UN Approval of Greenhouse Gas Emission Reduction Projects in Developing Countries?', *Public Choice*, **145** (1-2), 1-24.

Fredriksson, Per G., Eric Neumayer, Richard Damania and Scott Gates (2005), 'Environmentalism, Democracy, and Pollution Control', *Journal of Environmental Economics and Management*, **49** (2), 343-365.

Friberg, Lars and Paula Castro (2009), 'Análise Empírica Do Desempenho De Projetos MDL: Estudo De Caso Brasil', in Markus Brose (ed.), *O Pagamento Por Serviços Ambientais - O Mercado De Carbono Promove a Inclusão Social?*, Goiânia, Brazil: Care Brasil and Editora da Universidade Católica de Goiás .

Gan, Lin, Gunnar S. Eskeland and Hans H. Kolshus (2007), 'Green Electricity Market Development: Lessons From Europe and the US', *Energy Policy*, **35** (1), 144-155.

Garside, Ben (2009), 'EC Eyes a Smaller, Leaner Future for UN Offsets', *Point Carbon, Carbon Market News Daily*, January 29, available at http://www.pointcarbon.com/news/1.1046101 (accessed 30 January 2009).

Gastanaga, Victor M., Jeffrey B. Nugent and Bistra Pashamova (1998), 'Host Country Reforms and FDI Inflows: How Much Difference Do They Make?', *World Development*, **26** (7), 1299-1314.

Germain, Marc, Alphonse Magnus and Vincent Van Steenberghe (2007), 'How to Design and Use the Clean Development Mechanism Under the Kyoto Protocol? A Developing Country Perspective', *Environmental and Resource Economics*, **38** (1), 13-30.

Goldemberg, José (2006), 'The Promise of Clean Energy', *Energy Policy*, **34** (15), 2185-2190.

Gouchoe, Susan M., Valerie S. Everette and Rusty Haynes (2002), 'Case Studies on the Effectiveness of State Financial Incentives for Renewable Energy', Report NREL/SR-620-32819, Golden, CO: National Renewable Energy Laboratory.

Goulder, Lawrence H. and William A. Pizer (2006), 'The Economics of Climate Change', RFF Discussion Paper 06-06, Washington, D.C.: Resources for the Future.

De Gouvello, Christophe, Felix B. Dayo and Massamba Thioye (2008), 'Low-carbon Energy Projects for Development in Sub-Saharan Africa - Unveiling the Potential, Addressing the Barriers', Washington, D.C.: The World Bank.

Government of Malaysia (2011), 'Paragraph 87: Information on the Evaluation of Various Approaches in Enhancing the Cost-effectiveness Of, and Promoting, Mitigation Actions, Including Activities Implemented Jointly Under Article 4, Paragraph 2 (a), of the Convention and Any Other Relevant Activities, for Synthesis by the Secretariat', in UNFCCC Secretariat (ed.), *Views on the Evaluation of Various Approaches in Enhancing the Cost-effectiveness Of, and Promoting, Mitigation Actions - Submissions From Parties, FCCC/AWGLCA/2011/MISC.4*, Bonn: UNFCCC Secretariat. p. 12.

Government of Saudi Arabia (2011), 'Consideration of the Establishment of One or More Market based Mechanisms', in UNFCCC (ed.), *Views on the Elaboration of Market-based Mechanisms - Submissions From Parties, FCCC/AWGLCA/2011/MISC.2*, Bonn: UNFCCC Secretariat, pp. 79-80.

Government of Sri Lanka (2008), 'Views on How the Second Review of the Kyoto Protocol Pursuant to Its Article 9 Should Address, in Particular the Issues Identified by COP/MOP at Its Third Session', in UNFCCC (ed.), *Views on How the Issues Specified in Decision 4/CMP.3, Paragraph 6, Should Be Addressed in the Second Review of the Kyoto Protocol Pursuant to Its Article 9, and Information From Parties Included in Annex I to the Convention Demonstrating Progress Made in Implementing Their Commitments Under the Kyoto Protocol, Submissions From Parties - Addendum, FCCC/SBI/2008/MISC.2/Add.1*, Bonn: UNFCCC Secretariat. p. 24.

Greenpeace (2000), 'The Clean Development Mechanism: Used by Renewable Energy or Abused by Coal & Nuclear', Briefing Paper for SB 12, Bonn, Amsterdam: Greenpeace International.

Greiner, Sandra and Axel Michaelowa (2003), 'Defining Investment Additionality for CDM Projects— - Practical Approaches', *Energy Policy*, **31** (10), 1007-1015.

Gupta, Sujata, Dennis A. Tirpak, Nicholas Burger, Joyeeta Gupta, Niklas Höhne, Antonina I. Boncheva, Gorashi M. Kanoan, Charles Kolstad, Joseph A. Kruger, Axel Michaelowa, Shinya Murase, Jonathan Pershing, Tatsuyoshi Saijo and Agus Sari (2007a), 'Policies, Instruments and Co-operative Arrangements', in Bert Metz, Ogunlade R. Davidson, Peter R.

Bosch, Rutu Dave and Leo A. Meyer (eds.), *Climate Change 2007: Mitigation of Climate Change. Contribution of Working Group III to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change*, Cambridge, UK and New York, NY: Cambridge University Press, pp. 745-808.

Gupta, Joyeeta, Harro van Asselt, Onno Kuik and Chris Evans (2007b), 'Exogenous Promotion of Sustainable Electricity Policies in India: Opportunities and Challenges', *Energy & Environment*, **18** (3), 403-420.

Hagem, Cathrine and Bjart Holtsmark (2009), 'Does the Clean Development Mechanism Have a Viable Future?', Discussion Paper No. 577, Oslo: Research Department, Statistics Norway.

Harnisch, Jochen and Chris Hendriks (2000), 'Economic Evaluation of Emission Reduction of HFCs, PFCs and SF6 in Europe', Cologne: Ecofys.

Hartley, Cathy, Gareth Wyn Jones and Alison Neale (eds.) (2009), *The Environment Encyclopedia and Directory 2010,* 5th edition, London: Routledge.

Haya, Barbara (2009), 'Measuring Emissions Against An Alternative Future: Fundamental Flaws in the Structure of the Kyoto Protocol"s Clean Development Mechanism', Berkeley Energy and Resources Group Working Paper No. ERG09-001, Berkeley: University of California, Berkeley.

He, Gang and Richard K. Morse (2010), 'Making Carbon Offsets Work in the Developing World: Lessons From the Chinese Wind Controversy', Program on Energy and Sustainable Development Working Paper #90, Stanford, CA: Freeman Spogli Institute for International Studies, Stanford University.

Hepburn, Cameron (2007), 'Carbon Trading: A Review of the Kyoto Mechanisms', *Annual Review of Environment and Resources*, **32** 375-393.

Hepburn, Jarrod and Imran Ahmad (2005), 'The Principle of Common but Differentiated Responsibilities', Legal Working Paper in the CISDL "Recent Developments in International Law Related to Sustainable Development" Series, Montreal: Centre for International Sustainable Development Law.

High Level Group on Competitiveness, Energy and the Environment (2007), 'Addressing Both International Action on Climate Change and Better Regulation', Fifth Report of the HLG on Competitiveness, Energy and the Environment, available at http://ec.europa.eu/enterprise/policies/sustainable- business/policy-integration/high-level-group/reference-material/index_en.htm (accessed 12 April 2011).

Hourcade, Jean-Charles, Priyadarshi Shukla, Luis Cifuentes, Devra Davis, Jae Edmonds, Brian Fisher, Emeric Fortin, Alexander Golub, Olav Hohmeyer, Alan Krupnick, Snorre Kverndokk, Richard Loulou, Richard Richels, Hector Segenovic and Kenji Yamaji (2001), 'Global, Regional, and National Costs and Ancillary Benefits of Mitigation', in Bert Metz, Ogunlade R. Davidson, Rob Swart and Jiahua Pan (eds.), *Climate Change 2001: Mitigation. Contribution of Working Group III to the Third Assessment Report of the Intergovernmental Panel on Climate Change*, Cambridge, UK and New York, NY: Cambridge University Press, pp. 499-559.

Howse, Robert and Antonia Eliason (2009), 'Carbon Trading and the CDM in WTO Law', in Richard B Stewart, Benedict Kingsbury and Bryce Rudyk (eds.), *Climate Finance: Regulatory and*

Funding Strategies for Climate Change and Global Development, New York and London: New York University Press, pp. 254-258.

Höhne, Niklas, Gylvan M. Filho, Jacques Marcovitch, Farhana Yamin and Sara Moltmann (2007), 'History and Status of the International Climate Change Negotiations on a Future Climate Agreement', BASIC Project Paper 15, available at http://www.basic-project.net/data/final/Paper15Background%20Paper%20History%20and%20Status%20Climate%20Negotia%85.pdf (accessed 25 September 2009).

Hulme, Mike (2001), 'CRU Global Climate Dataset', Geneva: Intergovernmental Panel on Climate Change, available at http://geodata.grid.unep.ch (accessed 29 January 2011).

IEA (2007a), *CO_2 Emissions From Fossil Fuel Combustion 1971-2005,* Paris: OECD/IEA.

IEA (2007b), 'Key World Energy Statistics', Paris: OECD/IEA.

IEA (2010a), 'IEA CO_2 Highlights 2010', Paris: OECD/IEA.

IEA (2010b), *Renewables Information (2010 Edition),* Paris: OECD/IEA.

IEA (2012a), 'IEA CO_2 Highlights 2012', Paris: OECD/IEA.

IEA (2012b), 'IEA World Energy Balances', Paris: OECD/IEA, available at http://dx.doi.org/10.1787/data-00512-en (accessed 26 February 2013).

IGES (2010), 'IGES CDM Project Database', Kanagawa, Japan: Institute for Global Environmental Strategies, available at www.iges.or.jp/en/cdm/report_cdm.html (accessed 30 January 2011).

IGES (2011), 'IGES CDM ERs Calculation Sheet: Grid Emission Factors', Kanagawa, Japan: Institute for Global Environmental Strategies, available at http://enviroscope.iges.or.jp/modules/envirolib/view.php?docid=2136 (accessed 18 March 2011).

IMF (2008), 'World Economic Outlook Database 2008', Washington, D.C.: International Monetary Fund, available at https://www.imf.org/external/pubs/ft/weo/2008/01/weodata/index.aspx (accessed 20 November 2009).

Jackson, Tim and Katie Begg (1999), 'Accounting and Accreditation of Activities Implemented Jointly - Executive Summary', Contract No. ENV4-CT96-0210, EC Environment and Climate Research Programme (1994- 1998): Research Theme 4 – Human Dimensions of Climate Change, Guildford: Centre for Environmental Strategy, University of Surrey.

Jagadeesh, Anumakonda (2000), 'Wind Energy Development in Tamil Nadu and Andhra Pradesh, India Institutional Dynamics and Barriers—A Case Study', *Energy Policy*, **28** (3), 157-168.

Jamasb, Tooraj and Jonathan Köhler (2008), 'Learning Curves for Energy Technology and Policy Analysis: A Critical Assessment', in Michael Grubb, Tooraj Jamasb and Michael G. Pollitt (eds.), *Delivering a Low-carbon Electricity System: Technologies, Economics and Policy*, Cambridge, UK and New York, NY: Cambridge University Press, pp. 314-332.

Jimenez, G (2005), 'Policy Alternatives for Abatement of HFC-23 Emissions in China', *Sino Italian Workshop on HFC 23 CDM Projects in China*, 24 January 2005, Beijing.

John, Peter (1998), *Analysing Public Policy,* London: Continuum.

Johnson, Todd M., Claudio Alatorre, Zayra Romo and Feng Liu (2010), *Low-carbon Development for Mexico,* Washington, D.C.: World Bank.

Jung, Martina (2006), 'Host Country Attractiveness for CDM Non-sink Projects', *Energy Policy*, **34** (15), 2173-2184.

Junginger, H. Martin (2005), *Learning in Renewable Energy Technology Development,* PhD Dissertation, Utrecht University, Utrecht, The Netherlands: Department of Science, Technology and Society, Utrecht University.

Junginger, Martin, Andre Faaij and Wilhelmus C. Turkenburg (2005), 'Global Experience Curves for Wind Farms', *Energy Policy*, **33** (2), 133-150.

Karousakis, Katia, Bruno Guay and Cédric Philibert (2008), 'Differentiating Countries in Terms of Mitigation Commitments, Actions and Support', Report COM/ENV/EPOC/IEA/SLT(2008)2, Paris: OCDE/IEA.

Kaufmann, Daniel, Aart Kraay and Massimo Mastruzzi (2012), 'Worldwide Governance Indicators', Washington, D.C.: The World Bank, available at http://info.worldbank.org/governance/wgi/index.asp (accessed 10 February 2013).

Keller, Marius (2008), *Attracting Clean Investment - Explaining the Distribution of CDM Projects Across Host Countries,* PhD Dissertation, London School of Economics, London: London School of Economics.

Keohane, Robert O., Peter M. Haas and Marc A. Levy (1993), 'The Effectiveness of International Environmental Institutions', in Peter M. Haas, Robert O. Keohane and Marc A. Levy (eds.), *Institutions for the Earth: Sources of Effective International Environmental Protection*, Cambridge, MA: MIT Press, pp. 3-24.

Keohane, Robert O. and Joseph S. Nye (1989), *Power and Interdependence,* 2nd edition, Glenview, Ill: Scott, Foresman.

Kim, Joy Aeree (2001), 'Institutions in Conflict? The Climate Change Flexibility Mechanisms and the Multinational Trading System', *Global Environmental Change*, **11** (3), 251-255.

Kinkead, Belinda (2007), 'Undertaking CDM Projects in Africa – Challenges, Trends and Opportunities', *CDM DNA Forum*, 4 October 2007, Addis Ababa, Ethiopia: UNFCCC Secretariat, available at http://cdm.unfccc.int/DNA/DNAForum/03/presa/index.html (accessed 20 April 2009).

Knill, Christoph, Marc Debus and Stephan Heichel (2010), 'Do Parties Matter in Internationalised Policy Areas? The Impact of Political Parties on Environmental Policy Outputs in 18 OECD Countries, 1970–2000', *European Journal of Political Research*, **49** (3), 301-336.

Knoepfel, Peter, Corinne Larrue, Frédéric Varone and Michael Hill (2007), *Public Policy Analysis,* Bristol: Policy Press.

Kossoy, Alexandre and Philippe Ambrosi (2010), 'State and Trends of the Carbon Market 2010', Washington, D.C.: The World Bank.

Kozloff, Keith (1998), ' Electricity Sector Reform in Developing Countries: Implications for Renewable Energy', Washington, D.C.: Renewable Energy Policy Project.

Kuik, Onno, Luke Brander and Richard S. J. Tol (2009), 'Marginal Abatement Costs of Greenhouse Gas Emissions: A Meta-analysis', *Energy Policy*, **37** (4), 1395-1403.

Kverndokk, Snorre (1993), 'Coalitions and Side Payments in International CO_2 Treaties', Discussion Paper No. 97, Oslo, Norway: Research Department, Central Bureau of Statistics.

Laaksonen, Kalle, Petri Mäki-Fränti and Meri Virolainen (2007), 'Mauritius and Jamaica As Case Studies of the Lomé Sugar Protocol', Agricultural Trade Agreements Working Paper 06/21, Rennes: Institut National de la Recherche Agronomique, TradeAG.

Lenzen, Manfred, Roberto Schaeffer and Ryuji Matsuhashi (2007), 'Selecting and Assessing Sustainable CDM Projects Using Multi-criteria Methods', *Climate Policy*, **7** (2), 121-138.

Lester, James P., James L. Franke, Ann O. Bowman and Kenneth W. Kramer (1983), 'Hazardous Wastes, Politics, and Public-Policy - a Comparative State Analysis', *Western Political Quarterly*, **36** (2), 257-285.

Lim, David (1983), 'Fiscal Incentives and Direct Foreign Investment in Less Developed Countries', *The Journal of Development Studies*, **19** (2), 207-212.

Lim, Ewe-Ghee (2001), 'Determinants of and the Relation Between Foreign Direct Investment and Growth: A Summary of the Recent Literature', IMF Working Paper 01/175, Washington, D.C.: International Monetary Fund.

List, John A. and Daniel M. Sturm (2006), 'How Elections Matter: Theory and Evidence From Environmental Policy', *Quarterly Journal of Economics*, **121** (4), 1249-1281.

Lokey, Elizabeth (2009), *Renewable Energy Project Development Under the Clean Development Mechanism: A Guide for Latin America,* London: Earthscan.

Lütken, Søren E (2011), 'Indexing CDM Distribution: Leveling the Playing Field', CD4CDM Working Paper No. 10, Roskilde: UNEP Risø Centre.

Lütken, Søren E. and Axel Michaelowa (2008), *Corporate Strategies and the Clean Development Mechanism: Developing Country Financing for Developed Country Commitments?* Cheltenham: Edward Elgar.

Marques, António C., José A. Fuinhas and J. R. Pires Manso (2010), 'Motivations Driving Renewable Energy in European Countries: A Panel Data Approach', *Energy Policy*, **38** (11), 6877-6885.

Martinot, Eric (2002), 'Power Sector Restructuring and Environment: Trends, Policies and GEF Experience', Discussion paper for UNEP/IEA Brainstorming Meeting 'Power sector reform and sustainable development', May 21-22, 2002, Paris, Washington D.C.: Global Environment Facility.

Martinot, Eric, Akanksha Chaurey, Debra Lew, José Roberto Moreira and Njeri Wamukonya (2002), 'Renewable Energy Markets in Developing Countries', *Annual Review of Energy and the Environment*, **27** 309-348.

Matsui, Yoshiro (2002), 'Some Aspects of the Principle of "Common but Differentiated Responsibilities"', *International Environmental Agreements: Politics, Law and Economics*, **2** (2), 151-170.

McKitrick, Ross (1999), 'A Derivation of the Marginal Abatement Cost Curve', *Journal of Environmental Economics and Management*, **37** (3), 306-314.

Menanteau, Philippe, Dominique Finon and Marie-Laure Lamy (2003), 'Prices Versus Quantities: Choosing Policies for Promoting the Development of Renewable Energy', *Energy Policy*, **31** (8), 799-812.

Menz, Fredric C. and Stephan Vachon (2006), 'The Effectiveness of Different Policy Regimes for Promoting Wind Power: Experiences From the States', *Energy Policy*, **34** (14), 1786-1796.

Merton, Robert K. (1936), 'The Unanticipated Consequences of Purposive Social Action', *American Sociological Review*, **1** (6), 894-904.

Michaelowa, Axel (2000), 'The Relative Strength of Economic Interests in Shaping EU Climate Policy: A Hypothesis', *Energy & Environment*, **11** (3), 277-292.

Michaelowa, Axel (2003), 'CDM Host Country Institution Building', *Mitigation and Adaptation Strategies for Global Change*, **8** (3), 201-220.

Michaelowa, Axel (2004), 'The German Wind Energy Lobby - How to Successfully Promote Costly Technological Change', Hamburg: Hamburg Institute of International Economics.

Michaelowa, Axel (2008a), 'Demand and Supply on the International Carbon Markets', Unpublished Background Paper, Zurich: Perspectives for Climate Change.

Michaelowa, Axel (2008b), 'Discounting of CERs to Promote Integration of Developing Countries Into a Cap-and-trade System', Unpublished Background Paper, Zurich: University of Zurich.

Michaelowa, Axel, Sonja Butzengeiger and Martina Jung (2005), 'Graduation and Deepening: An Ambitious Post-2012 Climate Policy Scenario ', *International Environmental Agreements: Politics, Law and Economics*, **5** (1), 25-46.

Michaelowa, Axel and Frank Jotzo (2005), 'Transaction Costs, Institutional Rigidities and the Size of the Clean Development Mechanism', *Energy Policy*, **33** (4), 511-523.

Michaelowa, Axel and Pallav Purohit (2007), 'Additionality Determination of Indian CDM Projects. Can Indian CDM Project Developers Outwit the CDM Executive Board?', Climate Strategies Discussion Paper CDM-1, Cambridge, UK: Climate Strategies.

Ministry of Water and Environment, Republic of Yemen (2008), 'The Clean Development Mechanism (CDM) – Republic of Yemen', available at http://www.cdm-yemen.org/txtDetails.aspx?pageid=3 (accessed 26 April 2009).

Mitchell, Catherine, Dierk Bauknecht and Peter M. Connor (2006), 'Effectiveness Through Risk Reduction: A Comparison of the Renewable Obligation in England and Wales and the Feed-in System in Germany', *Energy Policy*, **34** (3), 297-305.

MNP (Netherlands Environmental Agency) (2008), 'Global CO_2 Emissions: Increase Continued in 2007', The Hague: Netherlands Environmental Agency, available at http://www.mnp.nl/en/publications/2008/GlobalCO2emissionsthrough2007.html (accessed 25 September 2009).

Mundlak, Yair (1978), 'On the Pooling of Time Series and Cross Section Data', *Econometrica*, **46** (1), 69-85.

Muyungi, Richard (2006), 'CDM for Sustainable Development: Dream or Reality – African Perspectives', *Presentation at UNFCCC COP12*, 8 November 2006, Nairobi, Kenya: UNFCCC Secretariat, available at http://www.iges.or.jp/en/news/cop12/cdm.html (accessed 20 April 2009).

Narain, Urvashi and Klaas van't Veld (2008), 'The Clean Development Mechanism's Low-hanging Fruit Problem: When Might It Arise, and How Might It Be Solved?', *Environmental & Resource Economics*, **40** (3), 445-465.

NASA (2005), 'Surface Meteorology and Solar Energy (SSE) Release 5 Data Set', Hampton, VA: NASA Langley Atmospheric Science Data Center, available at http://eosweb.larc.nasa.gov/sse/ (accessed 29 January 2011).

NASA (2008), 'Surface Meteorology and Solar Energy (SSE) Release 6.0 Data Set', Hampton, VA: NASA Langley Atmospheric Science Data Center, available at http://eosweb.larc.nasa.gov/sse/ (accessed 29 January 2011).

Nelson, Richard R. and Sidney G. Winter (1982), *An Evolutionary Theory of Economic Change,* Cambridge, MA: Harvard University Press.

Nemet, Gregory F. (2006), 'Beyond the Learning Curve: Factors Influencing Cost Reductions in Photovoltaics', *Energy Policy*, **34** (17), 3218-3232.

Neumayer, Eric (2003), 'Are Left-wing Party Strength and Corporatism Good for the Environment? Evidence From Panel Analysis of Air Pollution in OECD Countries', *Ecological Economics*, **45** (2), 203-220.

NSS Program (1999), 'Study on Flexibility Mechanisms Within the Context of the United Nations Framework Convention on Climate Change and the Kyoto Protocol', Washington, D.C.: National CDM/JI Strategy Studies (NSS) Program, The World Bank, available at http://web.worldbank.org/servlets/ECR?contentMDK=20480374&sitePK=406964 (accessed 15 July 2011).

Okubo, Yuri and Axel Michaelowa (2010), 'Effectiveness of Subsidies for the Clean Development Mechanism: Past Experiences with Capacity Building in Africa and LDCs', *Climate and Development*, **2** (1), 30-49.

Olsen, Karen Holm and Jørgen Fenhann (2008), 'Sustainable Development Benefits of clean development mechanism Projects: A New Methodology for Sustainability Assessment Based on Text Analysis of the Project Design Documents Submitted for Validation', *Energy Policy*, **36** (8), 2819 - 2830.

Olsen, Kim R. and Jyoti P. Painuly (2002), 'The Clean Development Mechanism: A Bane or a Boon for Developing Countries?', *International Environmental Agreements*, **2** (3), 237-260.

Olson, Mancur (1971), *The Logic of Collective Action: Public Goods and the Theory of Groups,* 2nd edition, Cambridge, MA: Harvard University Press.

Ostrom, Elinor (1990), *Governing the Commons: The Evolution of Institutions for Collective Action,* Cambridge, UK and New York: Cambridge University Press.

Ott, Hermann E., Harald Winkler, Bernd Brouns, Sivan Kartha, M. J. Mace, Saleemul Huq, Yasuko Kameyama, Agus P. Sari, Jiahua Pan, Youba Sokona, Preety M. Bhandari, Andrzej Kassenberg, Emilio Lèbre La Rovere and A. Atiq Rahman (2004), 'South–North Dialogue on Equity in the Greenhouse. A Proposal for An Adequate and Equitable Global Climate Agreement', Eschborn, Germany: Deutsche Gesellschaft für Technische Zusammenarbeit.

Parry, Martin L., Osvaldo F. Canziani, Jean P. Palutikof and Co-authors (2007), 'Technical Summary', in Martin L. Parry, Osvaldo F. Canziani, Jean P. Palutikof, Paul J. Van der Linden and C. E. Hanson (eds.), *Climate Change 2007. Impacts, Adaptation and Vulnerability. Contribution of Working Group II to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change*, Cambridge, UK and New York: Cambridge University Press, pp. 23-78.

Pew Center (2009), 'Pew Center Summary of H.R. 2454: American Clean Energy and Security Act of 2009 (Waxman-Markey)', available at http://www.pewclimate.org/docUploads/waxman-markey-detailed-summary-july2009.pdf (accessed 25 January 2010).

Rahman, Shaikh Mahfuzur, Don Larson and Ariel Dinar (2009), 'The Cost Structure of Emissions Abatement Through the Clean Development Mechanism', *Presentation at the Agricultural & Applied Economics Association's 2009 AAEA & ACCI Joint Annual Meeting*, 26 July 2009, Milwaukee, WI: AAEA.

Rajamani, Lavanya (2000), 'The Principle of Common but Differentiated Responsibility and the Balance of Commitments Under the Climate Regime', *Review of European Community and International Environmental Law (RECIEL)*, **9** (2), 120-131.

Rajsekhar, Budhavarapu, Frans Van Hulle and Jaap C. Jansen (1999), 'Indian Wind Energy Programme: Performance and Future Directions', *Energy Policy*, **27** (11), 669-678.

REN21 (2008), 'Renewable Energy Potentials in Large Economies - Summary Report', Paris: REN21 Secretariat.

REN21 (2010), 'Renewables 2010. Global Status Report', Paris: REN21 Secretariat.

REN21 (2012), 'Renewables 2012. Global Status Report', Paris: REN21 Secretariat.

Rennings, Klaus (2007), 'Comment: Approaches to the Modelling of Innovations for Sustainable Economic Systems', in Marco Lehmann-Waffenschmidt (ed.), *Innovations Towards Sustainability: Conditions and Consequences*, Heidelberg: Physica-Verlag, pp. 19-24.

Ringquist, Evan J. (1994), 'Policy Influence and Policy Responsiveness in State Pollution-Control', *Policy Studies Journal*, **22** (1), 25-43.

Rivers, Douglas and Quang H Vuong (1988), 'Limited Information Estimators and Exogeneity Tests for Simultaneous Probit Models', *Journal of Econometrics*, **39** (3), 347-366.

Roberts, J. Timmons, Martin Stadelmann and Saleemul Huq (2010), 'Copenhagen's Climate Finance Promise: Six Key Questions', IIED Briefing February 2010, London: International Institute for Environment and Development.

Roh, D. W. (2005), 'Estimation of Potential for Emissions Reductions and Energy Savings in Manufacturing Industry I (Cement Industry)', Uiwang, Korea: Korea Energy Economics Institute, available at http://www.keei.re.kr/main.nsf/index_en.html (accessed 27 March 2009).

Roh, D. W. (2006), 'Potential Estimation for GHG Emissions Reduction and Energy Efficiency in Manufacturing Industry II (oil Refining Industry) - Using Bottom-up Optimization Model (MARKAL)', Uiwang, Korea: Korea Energy Economics Institute, available at http://www.keei.re.kr/main.nsf/index_en.html (accessed 27 March 2009).

Roh, D. W. and Y. Y. Kang (2004), 'Study of the Effects of Policies on Greenhouse Gas Emission Reduction on the Productivity of the Manufacturing Industry', Uiwang, Korea: Korea Energy Economics Institute, available at http://www.keei.re.kr/main.nsf/index_en.html (accessed 27 March 2009).

Rohrschneider, Robert (1993), 'New Party Versus Old Left Realignments: Environmental Attitudes, Party Policies, and Partisan Affiliations in Four West European Countries', *Journal of Politics*, **55** (3), 682-701.

Root, Franklin R. and Ahmed A. Ahmed (1978), 'The Influence of Policy Instruments on Manufacturing Direct Foreign Investment in Developing Countries', *Journal of International Business Studies*, **9** (3), 81-93.

Root, Franklin R. and Ahmed A. Ahmed (1979), 'Empirical Determinants of Manufacturing Direct Foreign Investment in Developing Countries', *Economic Development and Cultural Change*, **27** (4), 751-767.

Rose, Adam, Erwin Bulte and Henk Folmer (1999), 'Long-run Implications for Developing Countries of Joint Implementation of Greenhouse Gas Mitigation', *Environmental and Resource Economics*, **14** (1), 19-31.

Rubin, Donald B (1987), *Multiple Imputation for Nonresponse in Surveys,* New York: Wiley.

Rudolph, Frederic (2007), 'Bewertung Des Beitrags Von CDM-Projekten Zur Nachhaltigen Entwicklung Seiner Gastländer', Policy Paper Nr. 3/2007, Wuppertal, Germany: Wuppertal Institut für Klima, Umwelt, Energie.

Samuelson, Paul A. (1954), 'The Pure Theory of Public Expenditure', *The Review of Economics and Statistics*, **36** (4), 387-389.

Sapat, Alka (2004), 'Devolution and Innovation: The Adoption of State Environmental Policy Innovations by Administrative Agencies', *Public Administration Review*, **64** (2), 141-151.

Schaffer, Mark E. and Steven Stillman (2010), 'Xtoverid: Stata Module to Calculate Tests of Overidentifying Restrictions After Xtreg, Xtivreg, Xtivreg2 and Xthtaylor', available at http://ideas.repec.org/c/boc/bocode/s456779.html (accessed 20 April 2013).

Schneider, Lambert (2007), 'Is the CDM Fulfilling Its Environmental and Sustainable Development Objectives? An Evaluation of the CDM and Options for Improvement', Report prepared for the WWF, Berlin: Öko-Institut.

Schneider, Lambert (2009), 'A Clean Development Mechanism with Global Atmospheric Benefits for a Post-2012 Climate Regime', *International Environmental Agreements-Politics Law and Economics*, **9** (2), 95-111.

Schneider, Lambert R. (2011), 'Perverse Incentives Under the CDM: An Evaluation of HFC-23 Destruction Projects', *Climate Policy*, **11** (2), 851-864.

Schneider, Friedrich and Bruno S. Frey (1985), 'Economic and Political Determinants of Foreign Direct Investment', *World Development*, **13** (2), 161-175.

Schneider, Lambert, Michael Lazarus and Anja Kollmuss (2010), 'Industrial N2O Projects Under the CDM: Adipic Acid - A Case of Carbon Leakage?', Working Paper WP-US-1006, Somerville, MA: Stockholm Environment Institute.

Schröder, Miriam (2009), 'Measuring the Impact of Chinese Provincial CDM Centres for Local Market Development', in Rob D. Van den Berg and Osvaldo Néstor Feinstein (eds.), *Evaluating Climate Change and Development*, New Brunswick, NJ: Transaction Publishers, pp. 193-212.

Sheinbaum, Claudia and Omar Masera (2000), 'Mitigating Carbon Emissions While Advancing National Development Priorities: The Case of México', *Climatic Change*, **47** (3), 259-282.

Shrestha, Ram M. and S. C. Bhattacharya (2002), 'Mitigating Environmental Emissions From the Power Sector: Analysis of Technical and Policy Options in Selected Asian Countries', *Presentation at COP 8*, 1 November 2002, New Delhi, India: UNFCCC Secretariat, available at http://unfccc.int/cop8/se/se_pres/aitc_se_cop8.pps (accessed 15 March 2010).

Silayan, Alan (2005), 'Equitable Distribution of CDM Projects Among Developing Countries', HWWA Report 255, Hamburg: Hamburg Institute of International Economics.

Singh, Harinder and Kwang W. Jun (1995), 'Some New Evidence on Determinants of Foreign Direct Investment in Developing Countries', World Bank Policy Research Working Paper No. 1531, Washington, D.C.: The World Bank, available at http://papers.ssrn.com/sol3/papers.cfm?abstract_id=623885.

Sirohi, Smita (2007), 'CDM: Is It a 'win-win' Strategy for Rural Poverty Alleviation in India?', *Climatic Change*, **84** (1), 91-110.

Solomon, Susan, Dahe Qin, Martin Manning, Richard B. Alley, Terje Berntsen, Nathaniel L. Bindoff, Zhenlin Chen, Amnat Chidthaisong, Jonathan M. Gregory, Gabriele C. Hegerl, Martin

Heimann, Bruce Hewitson, Brian J. Hoskins, Fortunat Joos, Jean Jouzel, Vladimir Kattsov, Ulrike Lohmann, Taroh Matsuno, Mario Molina, Neville Nicholls, Jonathan Overpeck, Graciela Raga, Venkatachalam Ramaswamy, Jiawen Ren, Matilde Rusticucci, Richard Somerville, Thomas F. Stocker, Ronald J. Stouffer, Penny Whetton, Richard A. Wood and David Wratt (2007), 'Technical Summary', in Susan Solomon, Dahe Qin, Martin Manning, Zhenlin Chen, Melinda Marquis, Kristen B. Averyt, Melinda Tignor and Henry L. Miller (eds.), *Climate Change 2007. The Physical Science Basis. Contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change*, Cambridge, UK and New York: Cambridge University Press, pp. 19-91.

Sprinz, Detlef and Tapani Vaahtoranta (1994), 'The Interest-based Explanation of International Environmental Policy', *International Organization*, **48** (01), 77-105.

Stadelmann, Martin and Paula Castro (2012), 'Good Copies or New Papers? Drivers for Renewable Energy Policies in Developing Countries', *Workshop "Climate Policy Innovation: Sources, Patterns and Effects"*, 23 February 2012, Amsterdam.

Stadelmann, Martin and Axel Michaelowa (2011), 'How to Enable the Private Sector to Mitigate? Building Capacity and Creating An Enabling Environment for Low-carbon Business Activities in Developing Countries', Climate Strategies Working Paper, Cambridge, UK: Climate Strategies.

Stern, Nicholas (2007), *The Economics of Climate Change: The Stern Review,* Cambridge, UK and New York: Cambridge University Press.

Stoft, Steven E. (2009), 'The CDM and Sectoral Crediting Mechanisms: Costs, Rents, and National Commitment Incentives', Carbonomics Consulting, available at http://stoft.com/metaPage/lib/Stoft-2009-09-Sectoral- Mechanism-Incentives.pdf (accessed 8 October 2009).

Sugiyama, Taishi and Axel Michaelowa (2001), 'Reconciling the Design of CDM with Inborn Paradox of Additionality Concept', *Climate Policy*, **1** (1), 75-83.

Sutter, Christoph and Juan Carlos Parreño (2007), 'Does the Current Clean Development Mechanism (CDM) Deliver Its Sustainable Development Claim? An Analysis of Officially Registered CDM Projects', *Climatic Change*, **84** (1), 75-90.

Tangen, Kristian and Gørild Heggelund (2003), 'Will the Clean Development Mechanism Be Effectively Implemented in China?', Report 8/2003, Lysaker, Norway: The Fridthof Nansen Institute.

Teorell, Jan, Nicholas Charron, Marcus Samanni, Sören Holmberg and Bo Rothstein (2011), 'The Quality of Government Dataset, Version 6 April 2011', Gothenburg: University of Gothenburg: The Quality of Government Institute, available at http://www.qog.pol.gu.se (accessed 5 June 2011).

Toman, Michael A., Richard D. Morgenstern and John Anderson (1999), 'The Economics of "when" Flexibility in the Design of Greenhouse Gas Abatement Policies', *Annual Review of Energy and the Environment*, **24** (1), 431-460.

Tosun, Jale (2011), 'Political Parties and Marine Pollution Policy: Exploring the Case of Germany', *Marine Policy*, **35** (4), 536-541.

Tsai, Pan-Long (1994), 'Determinants of Foreign Direct Investment and Its Impact on Economic Growth', *Journal of Economic Development*, **19** (1), 137-163.

Tsebelis, George (1995), 'Decision-Making in Political-Systems - Veto Players in Presidentialism, Parliamentarism, Multicameralism and Multipartyism', *British Journal of Political Science*, **25** 289-325.

Tsebelis, George (1999), 'Veto Players and Law Production in Parliamentary Democracies: An Empirical Analysis', *American Political Science Review*, **93** (3), 591-608.

Turner, R. Kerry, David Pearce and Ian Bateman (1993), *Environmental Economics: An Elementary Introduction,* Baltimore: Johns Hopkins University Press.

UN (1992), *United Nations Framework Convention on Climate Change,* New York: United Nations.

UN (1998), *Kyoto Protocol to the United Nations Framework Convention on Climate Change,* New York: United Nations.

Underdal, Arild (2004), 'Methodological Challenges in the Study of Regime Effectiveness', in Arild Underdal and Oran R. Young (eds.), *Regime Consequences: Methodological Challenges and Research Strategies*, Dordrecht, The Netherlands: Kluwer Academic Publishers, pp. 27-48.

UNDP (2010), *Human Development Report 2010,* New York: Palgrave Mcmillan.

UNDP and GEF (1999), 'Economics of Greenhouse Gas Limitations. Country Study Series: Argentina', Roskilde: UNEP Collaborating Centre on Energy and Environment, Risoe National Laboratory.

UNEP (2007), 'UNEP's CDM Activities in Africa: An Overview', *Presentation at SB26 Side Event Implementing the Nairobi Framework - A Mobilization Event*, 14 May 2007, Bonn: UNFCCC Secretariat, available at http://unfccc.int/meetings/sb26/side_events_and_exhibits/items/3982.php (accessed 20 April 2009).

UNEP Risoe Centre (2009), 'CDM/JI Pipeline Analysis and Database', 01 January 2009, Roskilde: UNEP Risoe Centre, available at http://www.cdmpipeline.org/ (accessed 12 January 2009).

UNEP Risoe Centre (2010), 'CDM/JI Pipeline Analysis and Database', 01 January 2010, Roskilde: UNEP Risoe Centre, available at http://www.cdmpipeline.org/ (accessed 24 January 2010).

UNEP Risoe Centre (2011a), 'CDM/JI Pipeline Analysis and Database', 01 February 2011, Roskilde: UNEP Risoe Centre, available at http://www.cdmpipeline.org/ (accessed 15 February 2011).

UNEP Risoe Centre (2011b), 'CDM/JI Pipeline Analysis and Database', 01 August 2011, Roskilde: UNEP Risoe Centre, available at http://www.cdmpipeline.org/ (accessed 5 August 2011).

UNEP Risoe Centre (2012), 'CDM/JI Pipeline Analysis and Database', 01 January 2012, Roskilde: UNEP Risoe Centre, available at http://www.cdmpipeline.org/ (accessed 15 January 2012).

UNEP TEAP (2002), 'Report of the UNEP Technology and Economic Assessment Panel – Volume 3B: Report of the Task Force on Destruction Technologies', Nairobi: UNEP Technology and Economic Assessment Panel.

UNFCCC (n.d), 'CDM Project Cycle', available at http://cdm.unfccc.int/Projects/diagram.html (accessed 14 April 2013).

UNFCCC (2001a), 'Report of the Conference of the Parties on Its Seventh Session, October 29 – November 10, 2001. Addendum. Part Two: Action Taken by the Conference of the Parties, Volume I', FCCC/CP/2001/13/Add.1, Marrakesh: UNFCCC Secretariat.

UNFCCC (2001b), 'Report of the Conference of the Parties on Its Seventh Session, October 29 – November 10, 2001. Addendum. Part Two: Action Taken by the Conference of the Parties, Volume II', FCCC/CP/2001/13/Add.2, Marrakesh: UNFCCC Secretariat.

UNFCCC (2005a), 'Decision 3/CMP.1 – Modalities and Procedures for a Clean Development Mechanism As Defined in Article 12 of the Kyoto Protocol', in *Report of the Conference of the Parties Serving As the Meeting of the Parties to the Kyoto Protocol on Its First Session, Held at Montreal From 28 November to 10 December 2005. Addendum. Part Two: Action Taken by the Conference of the Parties Serving As the Meeting of the Parties to the Kyoto Protocol at Its First Session, FCCC/KP/CMP/2005/8/Add.1*, Montreal: UNFCCC Secretariat, pp. 6-29.

UNFCCC (2005b), 'Decision 4/CMP.1 – Guidance Relating to the Clean Development Mechanism', in *Report of the Conference of the Parties Serving As the Meeting of the Parties to the Kyoto Protocol on Its First Session, Held at Montreal From 28 November to 10 December 2005. Addendum. Part Two: Action Taken by the Conference of the Parties Serving As the Meeting of the Parties to the Kyoto Protocol at Its First Session, FCCC/KP/CMP/2005/8/Add.1*, Montreal: UNFCCC Secretariat, pp. 30-60.

UNFCCC (2005c), 'Decision 7/CMP.1 – Further Guidance Relating to the Clean Development Mechanism', in *Report of the Conference of the Parties Serving As the Meeting of the Parties to the Kyoto Protocol on Its First Session, Held at Montreal From 28 November to 10 December 2005. Addendum. Part Two: Action Taken by the Conference of the Parties Serving As the Meeting of the Parties to the Kyoto Protocol at Its First Session, FCCC/KP/CMP/2005/8/Add.1*, Montreal: UNFCCC Secretariat, pp. 93-99.

UNFCCC (2008a), 'Emissions Trading and the Project-based Mechanisms: Draft Conclusions Proposed by the Chair', FCCC/KP/AWG/2008/L.8, Bonn: UNFCCC Secretariat.

UNFCCC (2008b), 'GHG Emission Profiles for Annex I Parties and Major Groups', Bonn: UNFCCC Secretariat, available at http://unfccc.int/ghg_data/ghg_data_unfccc/ghg_profiles/items/4625.php (accessed 5 May 2009).

UNFCCC (2008c), 'Report of the Conference of the Parties on Its Thirteenth Session, Held in Bali From 3 to 15 December 2007. Addendum. Part Two: Action Taken by the Conference of the Parties at Its Thirteenth Session', FCCC/CP/2007/6/Add.1, Bonn: UNFCCC Secretariat.

UNFCCC (2008d), 'Report of the Conference of the Parties Serving As the Meeting of the Parties to the Kyoto Protocol on Its Third Session, Held in Bali From 3 to 15 December 2007, Addendum - Part Two: Action Taken by the Conference of the Parties Serving As the Meeting of the Parties to the Kyoto Protocol at Its Third Session', FCCC/KP/CMP/2007/9/Add.1, Decision 4/CMP.3, Bonn: UNFCCC Secretariat.

UNFCCC (2008e), 'Synthesis of Views on How the Issues Specified in Decision 4/CMP.3, Paragraph 6, Should Be Addressed in the Second Review of the Kyoto Protocol Pursuant to Its Article 9: Note by the Secretariat', FCCC/SBI/2008/INF.1, Bonn: UNFCCC Secretariat.

UNFCCC (2009), 'Draft Decision -/CMP.5. Further Guidance Relating to the Clean Development Mechanism', FCCC/KP/CMP/2009/L.10, Bonn: UNFCCC Secretariat.

Union of International Associations (2012), 'Yearbook of International Organizations Online', Brussels: Union of International Associations, available at http://ybio.brillonline.nl/ (accessed 27 January 2013).

Uprety, Batu Krishna (2006), 'Clean Development Mechanism and Poverty Reduction', *Presentation at the Workshop Developing a Regional Strategy for the CDM in Asia and the Pacific Region*, 30 March 2006, Bangkok: IGES, available at http://www.iges.or.jp/en/cdm/pdf/regional/activity_regional01/19.pdf (accessed 25 April 2009).

US EIA (2008a), 'Annual Energy Outlook 2008 – with Projections to 2030', Washington, D.C.: US Department of Energy, Energy Information Administration.

US EIA (2008b), 'International Energy Outlook 2008', Washington, D.C.: US Department of Energy, Energy Information Administration.

US EIA (2009), 'International Energy Outlook 2009', Report DOE/EIA-0484(2009), Washington, D.C.: U.S. Department of Energy, Energy Information Administration.

US EIA (2011), 'International Electricity Prices and Fuel Costs', Washington, D.C.: US Department of Energy, Energy Information Administration.

US EIA (2012), 'International Energy Statistics', Washington, D.C.: US Department of Energy, Energy Information Administration, available at http://www.eia.gov/countries/data.cfm (accessed 20 February 2013).

US EPA (2006), 'Global Mitigation of Non-CO_2 Greenhouse Gases - Technical Annex', Report 430-R-06-005, Washington, D.C.: US Environmental Protection Agency, available at http://www.epa.gov/methane/excel/techtbls.xls (accessed 27 September 2009).

US Government Accountability Office (2008), 'International Climate Change Programs: Lessons Learnt From the European Union's Emissions Trading Scheme and the Kyoto Protocol's Clean Development Mechanism', Report GAO-09-151, Washington, D.C.: US GAO.

Vachon, Stephan and Fredric C. Menz (2006), 'The Role of Social, Political, and Economic Interests in Promoting State Green Electricity Policies', *Environmental Science & Policy*, **9** (7-8), 652-662.

Vattenfall (2007), 'Global Mapping of Greenhouse Gas Abatement Opportunities Up to 2030', Stockholm: Vattenfall, available at http://www.vattenfall.com/www/ccc/ccc/569512nextx/index.jsp (accessed 15 September 2008).

Wara, Michael (2008), 'Measuring the Clean Development Mechanism's Performance and Potential', *UCLA Law Review*, **55** (6), 1759-1803.

Wara, Michael and David Victor (2008), 'A Realistic Policy of International Carbon Offsets', Working Paper No. 74, Stanford: Program on Energy and Sustainable Development, Stanford University.

Waste Concern (2006), 'CDM Bangladesh: Clean Development Mechanism (CDM)', available at http://cdmbangladesh.net/index.htm (accessed 26 April 2009).

Werksman, Jacob (1998), 'The Clean Development Mechanism: Unwrapping the 'Kyoto Surprise'', *Review of European Community & International Environmental Law*, **7** (2), 147-158.

Wetzelaer, Bas J. H. W., Nico H. van der Linden, Heleen C. de Coninck and Heleen Groenenberg (2007), 'GHG Marginal Abatement Cost Curves for the Non-Annex I Region'', ECN report No. ECN-E--06--060, Petten: Energy Research Centre of the Netherlands.

Winkelman, Andrew G. and Michael R. Moore (2011), 'Explaining the Differential Distribution of Clean Development Mechanism Projects Across Host Countries', *Energy Policy*, **39** (3), 1132-1143.

Winkler, Harald, Andrew Marquard, Jonathan Manley, Stephen Davis, Ajay Trikam, Michel Den Elzen, Niklas Höhne and Jongikhaya Witi (2008), 'Quantifying SD-PAMs: National Energy Models and International Allocation Models for Climate Change Mitigation: South African Case Study', Cape Town, South Africa: Energy Research Centre, University of Cape Town.

Winkler, Harald and Steve Thorne (2002), 'Baselines for Suppressed Demand: CDM Projects Contribution to Poverty Alleviation', *South African Journal of Economic and Management Sciences*, **5** (2), 413-429.

Wiser, Glenn (2002), 'Frontiers in Trade: The Clean Development Mechanism and the General Agreement on Trade in Services', *International Journal of Global Environmental Issues*, **2** (3-4), 288-309.

Wooldridge, Jeffrey M. (2002), *Econometric Analysis of Cross Section and Panel Data,* Cambridge, MA: MIT Press.

Wooldridge, Jeffrey M. (2010), *Econometric Analysis of Cross Section and Panel Data,* 2nd edition, Cambridge, MA: MIT Press.

World Bank (2002), 'South African National Strategy Study on the Clean Development Mechanism', Washington, D.C.: The World Bank.

World Bank (2003), 'Host Country Concerns in CF Deals: Questions and Answers, CFB Implementation Note No. XX, Draft for Host Country Committee Meeting', Washington, D.C.: World Bank Carbon Finance Unit, available at http://wbcarbonfinance.org/docs/HCCconcernsinCFDeals.doc (accessed 28 July 2011).

World Bank (2007), 'Nairobi Framework – Capacity Building in Africa', *Presentation at SB26 Side Event Implementing the Nairobi Framework - A Mobilization Event*, 14 May 2007, Bonn: UNFCCC Secretariat, available at http://unfccc.int/meetings/sb26/side_events_and_exhibits/items/3982.php (accessed 20 April 2009).

World Bank (2010), 'World Development Indicators', CD Rom, Washington, D.C.: The World Bank.

World Bank (2012), 'World Development Indicators', CD Rom, Washington, D.C.: The World Bank.

WRI (2008), 'Climate Analysis Indicators Tool (CAIT) Version 5.0', Washington D.C.: World Resources Institute, available at http://cait.wri.org/ (accessed 25 September 2009).

WRI (2009), 'Summary of UNFCCC Submissions. August 2008 – October 2009', Working Paper, Washington, D.C.: World Resources Institute.

WRI (2010), 'Summary of Climate Finance Pledges Put Forward by Developed Countries', Washington, D.C.: World Resources Institute, available at http://pdf.wri.org/climate_finance_pledges_2010-03-04.pdf (accessed 28 August 2010).

WWF (2007), 'Climate Witness: Jalaluddin Saha, India', available at http://wwf.panda.org/about_our_earth/aboutcc/problems/people_at_risk/personal_stories/ witness_stories/?uNewsID=100900 (accessed 30 July 2011).

Yamaguchi, Mitsutsune (2003), 'CDM Potential of Electric Power Sector and Energy-intensive Industries in China. Outcome of 5-year Joint Study of Keio University/Tsinghua

University', *Presentation at COP 9*, 8 December 2003, Milan, Italy: UNFCCC Secretariat, available at http://m-yamaguchi.jp/english_page/CDM2004.pdf.

Yamaguchi, Mitsutsune (2005), 'CDM Potential in the Power-generation and Energy-intensive Industries of China', *Climate Policy*, **5** (2), 167-184.

Young, Oran R. (1982), 'Regime Dynamics: The Rise and Fall of International Regimes', *International Organization*, **36** (2), 277-297.

Young, Oran R. (2004), 'The Consequences of International Regimes. A Framework for Analysis', in Arild Underdal and Oran R. Young (eds.), *Regime Consequences: Methodological Challenges and Research Strategies*, Dordrecht, The Netherlands: Kluwer Academic Publishers, pp. 2-23.

Paula M. Castro Pareja

Contact Information

Department of Political Science
University of Zurich
Affolternstrasse 56
8050 Zurich, Switzerland

Cell: +41-767 20 2166
E-mail: castro@pw.uzh.ch
paulacastrop@yahoo.com

Citizenship

Peruvian

Education

University of Zurich, Zurich, Switzerland

Doctoral candidate, Political Science (expected October 2011)

- Center for Comparative and International Studies
- Area of Study: International Climate Policy
- Thesis: *The CDM and incentives for climate change mitigation in developing countries*
- Advisors: Prof. Dr. Katharina Michaelowa, Dr. Axel Michaelowa
- Committee: Prof. Dr. Katharina Michaelowa, Prof. Dr. Joyeeta Gupta, Dr. Regina Betz

The University of Reading, Reading, UK

M.Sc., Environment and Development, December 2006

- International and Rural Development Deparment
- Thesis: *Governance in combating desertification in Peru: The case of Apurimac Region* (Passed with Distinction)

National Agrarian University La Molina, Lima, Peru

Environmental Engineer, April 2004

- Faculty of Sciences
- Thesis: *Recovery of organic matter from fish industry wastewater for use as nitrogen source in agricultural soils* (Outstanding)

B.Sc., Environmental Engineering, December 2002

- First in order of merit of her year

Additional Training

University of Essex, Colchester, UK

Essex Summer School in Social Science Data Analysis and Collection

- 2009: Panel Data Analysis for Comparative Research, Prof. Christopher Adolph
- 2008: Introduction to Limited Dependent Variable Models, Prof. Garrett Glasgow

Vrije Universiteit Amsterdam, Amsterdam, Netherlands

PhD Summer School in Earth System Governance (August 2008)

Grants and Awards

Swiss Academy of Humanities and Social Sciences (2011): Grant for participation in the Midwest Political Science Association 2011 Annual Conference (CHF 1'000)

University of Zurich, Department for Political Science (2010): Professors' distinction for special services to the department (CHF 3'000)

University of Zurich (2010–2011): Grant for the continuation of the Peer Mentoring Group PoliNet (CHF 17'000)

Swiss Academy of Humanities and Social Sciences (2010): Grant for participation in the Fourth World Congress of Environmental and Resource Economists (CHF 1'500)

Swiss National Science Foundation (2009): Grant for participation in the Essex Summer School in Social Science Data Analysis and Collection (CHF 2'700)

University of Zurich (2008–2009): Grant for the constitution of the Peer Mentoring Group PoliNet (CHF 18'000)

EU Alban Programme (2005–2006): Scholarship for the MSc studies at the University of Reading, UK (EUR 18'000)

German Academic Exchange Service (1998): Scholarship for a summer school on German language and culture at the Fachhochschule Fulda, Germany

Academic Experience

University of Zurich, Department for Political Science, Zurich, Switzerland

Teaching Assistant **September 2008 to present**

- Tutor: Kernkompetenzen Politische Ökonomie (Autumn 2008, 2009, 2010)
- Course lecturer: Sustainable development and international environmental policy (Spring 2009, 2010)
- Coordinator of the online content (OLAT) for the courses at the Chair of Political Economy and Development (Autumn 2009)

Research assistant **December 2007 to present**

- Conducted research for the projects:
  - Empirical analysis of performance of CDM projects
  - Role of Sub-Saharan Africa and Least Developed Countries in the CDM
  - Eigene Emissionsminderungsbeiträge in Schwellen- und Entwicklungsländern jenseits einer reinen Kompensation (Own emission reduction contributions in emerging and developing countries beyond pure offsetting)
  - Sektorale Ansätze als Beteiligungsoption für Schwellenländer in einem Klimaregime nach 2012 (Sectoral approaches as option for the participation of emerging economies in a climate regime post 2012)
  - Negotiating Climate Change
  - Linking public finance and market mechanisms in the post-2012 climate regime
  - Analysis of approaches for international project-based offset mechanisms
  - Ausgestaltung des Post 2012-Klimaregimes: Ausgestaltung der Marktmechanismen (Design of the post-2012 climate regime: Market mechanisms)
  - Ausgestaltung des Post 2012-Klimaregimes: Sektorale Ansätze zur THG-Emissionsminderung (Design of the post-2012 climate regime: Sectoral approaches to reduce greenhouse gases)

National Agrarian University La Molina, Faculty of Agricultural Engineering, Lima, Peru

Teaching Assistant **March 2004 - September 2005**

- Lab sessions on biomass energy for undergraduate and M.Sc. level courses
- Instructor at extension courses on biodiesel production and use

Research Assistant **July 2003 - September 2005**

- Project: Options for biodiesel production in Peru
  - Laboratory, field and literature research on the technological, economic, social, legal and environmental aspects of biodiesel production
  - Preparation of reports, papers, research proposals and webpage
  - Budget managing and supervision of interns
  - Communication and networking activities

Other Work Experience

Practical Action, Lima, Peru

Consultant **November 2006 to November 2007**

- Support for the preparation of a diagnostic, plan of action and terms of reference for the Strategic Plan for Sustainable Energy and Biofuels in Peru

- Preparation of publication on biodiesel production and use

CooperAccion, Lima, Peru

Consultant **May to September 2003**

- Compilation and processing of quantitative and qualitative information on demography, economics, poverty and main activities in the Peruvian Coastal Zone

Swiss Agency for Development and Cooperation, PyMAGROS Project, Lima, Peru

Consultant **August to November 2002**

- Preparation of the study Certified organic products offer in Peru

Santiago de Surco Municipality, Lima, Peru

Intern **January 2001 to June 2002**

- Municipal solid waste recycling programme
- Instructor in workshops on environmental education and guided visits for school and university students, local neighbours and municipality staff
- Preparation of didactic material for the environmental education programme
- Coordination and supervision of the project Special solid waste management

Service to the Profession

Referee for *International Environmental Agreements: Politics, Law and Economics*; *Climate and Development*

Organisation of the 21st Ph.D. Workshop on International Climate Policy (2010)

Responsible for the finances of the Peer Mentoring group PoliNet (2010-2011)

Member of the student representation at the Faculty of Sciences, National Agrarian University La Molina (2001)

Language and IT Skills

Languages:

- Spanish: mother tongue
- English, German: fluent
- French: intermediate
- Portuguese: passive knowledge

IT:

- General: Microsoft Office, other common packages for Windows and OS X, LaTeX
- Statistics: MiniTab, SPSS, Stata, R
- Other: Access, AutoCad 2000, ArcView, Surfer, Photoshop

Publications

Climate Policy: Journal articles

Castro P. (2011). Does the CDM discourage emission reduction targets in advanced developing countries? *Climate Policy*, online: DOI:10.1080/14693062.2011.592658. (Previously published as: Castro P. Climate Change Mitigation in Advanced Developing Countries: Empirical Analysis of the Low-hanging Fruit Issue in the Current CDM *CIS Working Paper 54*, Center for Comparative and International Studies, ETH Zurich and University of Zurich, March 2010).

Castro P., Michaelowa A. (2011). Would preferential access measures be sufficient to overcome current barriers to CDM projects in Least Developed Countries? *Climate and Development* 3, 123-142. (Previously published as: Castro P., Michaelowa A. Would preferential access to the EU ETS be sufficient to overcome current barriers to CDM projects in LDCs? *Climate Strategies Discussion Paper*, March 2009).

Castro P., Michaelowa A. (2010). The impact of discounting emission credits on the competitiveness of different CDM host countries. *Ecological Economics* 70, 34-42.

Climate Policy: Book chapters

Buen J., Castro P. (forthcoming). How Brazil and China have financed industry development and energy security initiatives that support mitigation objectives. In: (Axel Michaelowa, ed.): *Carbon Markets or Climate Finance: Low Carbon and Adaptation Investment Choices for the Developing World*, Earthscan, Oxford.

Friberg L., Castro P. (2009). Análise empírica do desempenho de projetos MDL: Estudo de caso Brasil. In: (Markus Brose, ed.): *O pagamento por serviços ambientais - O mercado de carbono promove a inclusão social?*, Care Brasil, Editora da Universidade Católica de Goiás, Goiânia, Brazil, pp. 123-147. (Published previously as: Empirical analysis of performance of CDM projects: case study Brazil. *Climate Strategies Discussion Paper CDM-8*, March 2008).

Climate Policy: Work in progress and discussion papers

Castro P., Hörnlein L., Michaelowa Katharina (2011). Path Dependence of Negotiation Structures in International Organizations: The Impact of Annex I Membership on Discussions within the UNFCCC. *CIS Working Paper 67*, Center for Comparative and International Studies, ETH Zurich and University of Zurich, May 2011.

Castro P., Benecke, G. (2008). Empirical analysis of performance of CDM projects: case study India. *Climate Strategies Discussion Paper CDM-7*, March 2008.

Castro P. (2008). Empirical analysis of performance of CDM projects: case study China. *Climate Strategies Discussion Paper CDM-6*, March 2008.

Castro P., Michaelowa A. (2007). Opinions of project developers regarding performance of CDM projects. *Climate Strategies Discussion Paper CDM-5*, November 2007.

Castro P. (2007). Empirical analysis of performance of CDM projects: rejections and withdrawals. *Climate Strategies Discussion Paper CDM-4*, November 2007.

Climate Policy: Conference papers

Castro P. (2011). Greenhouse Gas Emission Reduction Technologies: What Determines their Access to the Clean Development Mechanism? Paper presented at the *2011 Midwest Political Science Association Annual Conference*, Chicago, USA, 31 March - 3 April 2011.

Castro P., Hörnlein L., Michaelowa K. (2011). Path Dependence of Negotiation Structures in International Organizations: The Impact of Annex I Membership on Discussions within the UNFCCC. Paper presented at the *2011 Meeting of the European Public Choice Society*, Rennes, France, 28 April - 1 May 2011, the *2011 Midwest Political Science Association Annual Conference*, Chicago, USA, 31 March - 3 April 2011, and the *3-Länder-Tagung 2011*, Workshop on *Intergration, cooperation and the environment*, University of Basel, Switzerland, 13-14 January 2011.

Castro P. (2010). Climate change mitigation in advanced developing countries: Empirical analysis of the low-hanging fruit issue in the CDM. Paper presented at the *Fourth World Congress of Environmental and Resource Economists*, Université du Québec à Montréal, Canada, 28 June - 2 July 2010, and the *Annual Congress of the Swiss Political Science Association*, University of Geneva, Switzerland, 7-8 January 2010.

Castro P. (2009). The CDM, the low-hanging fruit issue and post-2012 climate policy. Paper presented at the *Conference on the International Dimensions of Climate Policies*, University of Bern, Switzerland, 21-23 January 2009.

Climate Policy: Research reports

Castro, P., Hayashi, D., Kristiansen, K.O., Michaelowa, A., Stadelman, M. (2011). Linking RE Promotion Policies with International Carbon Trade (LINK) - Scoping study for IEA-RETD. Available here.

Butzengeiger-Geyer, S., Castro P., Harthan, R.O., Hayashi, D., Healy, S., Maribu, K.M., Michaelowa A., Okubo, Y., Schneider, L., Storrø, I. (2010). Options for utilizing the CDM for global emission reductions. Report UBA-FB 001414/E, German Federal Environment Agency, Dessau-Ro, Germany. Available here.

Castro P., Michaelowa A. (2008). Empirical analysis of performance of CDM projects: final report. Climate Strategies, Cambridge, UK.

Biofuels: Peer-reviewed publications and conference papers

Coello J., Castro P. (2008). Biocombustibles, agua y agricultura en los Andes (Biofuels, water and agriculture in the Andes). *Revista Virtual REDESMA*, Centro Boliviano de Estudios Multidisciplinarios, Julio 2008.

Calle J., Coello J., Castro P. (2005). Options for biodiesel production in Peru. *Mosaico Científico* 2(2): 70-77.

Calle J., Coello J., Castro P., Acosta F., Nazario M. (2003). Options for small-scale biodiesel production in Peru. Paper presented at the *X Peruvian Symposium of Solar Energy (XSPES)*, November 2003, Cusco, Peru.

Biofuels: Monographs

Acosta F., Castro P., Cortijo E. (2008). *Manual de construcción y uso de reactor para producción de biodiesel a pequeña escala* (Handbook for building and using a reactor for small-scale biodiesel production). Lima: Soluciones Prácticas-ITDG. 54 pp.

Castro P., Coello J., Castillo L. (2007). *Opciones para la producción y uso de biodiesel en el Perú* (Options for biodiesel production and use in Peru). Lima: Soluciones Prácticas-ITDG. 176 pp.

Other publications

Castro P. (2010). *Governance in combating desertification in Peru: The case of Apurimac Region.* Saarbrücken, Germany: Lambert Academic Publishing. 116 pp.

Sueiro J., Cornejo A., Castro P. (2005). *La zona costera peruana: recursos, usos y gestión* (The Peruvian coastal zone: resources, uses and management). Lima: CooperAcción. 137 pp.

Bandenay L., Castro P., González Y., Inami F., Ruiz K., Viale L. (2002). *Escuela Itinerante de Educación Ambiental – Cuaderno del Alumno* (Travelling School of Environmental Education, Student book). Lima: Santiago de Surco Municipality.

Bandenay L., Castro P., Yaya P. (2002). *Cuentos del Medio Ambiente* (Tales of the Environment). Collection of six children short stories about environment and recycling. Lima: Santiago de Surco Municipality.

Castro P. (2002). *Certified Organic Products Market in Peru 2001.* Study divulgation brochure. Lima: Swiss Agency for Development and Cooperation.

Other talks

"The vulnerable developing countries: Drawing resources out of need", with Carola Betzold and Florian Weiler, UN Climate Change Conference June 2011, Side Event "Building capacity of developing country leaders and negotiators to influence international talks", 6-17 June 2011, Maritim Hotel, Bonn, Germany.

"CDM Standardization - Latest advances in research", 16th UNFCCC Climate Change Conference, Side Event "Standardizing CDM - towards zero transaction cost?", 29 November - 10 December 2010, Cancunmesse, Cancun, Mexico.

"Measuring, reporting and verifying mitigation actions by developing countries: Topics for discussion", 2010 European Capacity Building Initiative Oxford Fellowhships, 25-31 August 2010, University of Oxford, Oxford, UK.

"Preferential access measures to overcome current barriers to CDM projects in LDCs", Bonn Climate Change Talks 2010, Side Event "CDM after COP 15 - How to promote the mechanism in underrepresented countries", 31 May - 11 June 2010, Maritim Hotel, Bonn, Germany.

"Piece of cake? Sectoral approaches and NAMA crediting", Carbon Market Insights 2010, 2-4 March 2010, RAI Amsterdam, Amsterdam, Netherlands.

"Crediting NAMAs: Challenges and opportunities", Carbon Market Insights 2010, Workshop "The new mechanisms - What do sectoral mechanisms and NAMAs mean for the market?", 4 March 2010, RAI Amsterdam, Amsterdam, Netherlands.

"Options to further develop existing mechanisms: Discounting approaches and standardised baselines", Copenhagen Climate Conference 2009, Side Event "Using the carbon market post-2012 to incentivise ambitious NAMAs", 7-18 December 2009, Bella Center, Copenhagen, Denmark.

"Sectoral approaches - panacea or dead-end street?", Barcelona Climate Change Talks 2009, Side Event "CDM post 2012 - Dissecting a mechanism at the frontiers", 2-6 November 2009, Fira Gran Via, Barcelona, Spain.

"How to move the CDM beyond offsetting in a post-2012 climate regime?", Bonn Climate Change Talks 2009, Side Event "How to move the CDM beyond offsetting in a post-2012 climate regime?", 2-13 June 2009, Maritim Hotel, Bonn, Germany.

"The CDM, the low-hanging fruit issue and post-2012 climate policy", UNCTAD Expert Meeting: Trade and investment opportunities and challenges under the Clean Development Mechanism (CDM), 27-29 April 2009, Palais des Nations, Geneva, Switzerland.

"Can discounting or a preferential access to the EU market provide a sufficient incentive for projects in LDCs?", Carbon Market Insights 2009, Side Event "CDM reform - Perspectives from Africa, China and India", 17-19 March 2009, Bella Center, Copenhagen, Denmark.

Zurich, August 2011